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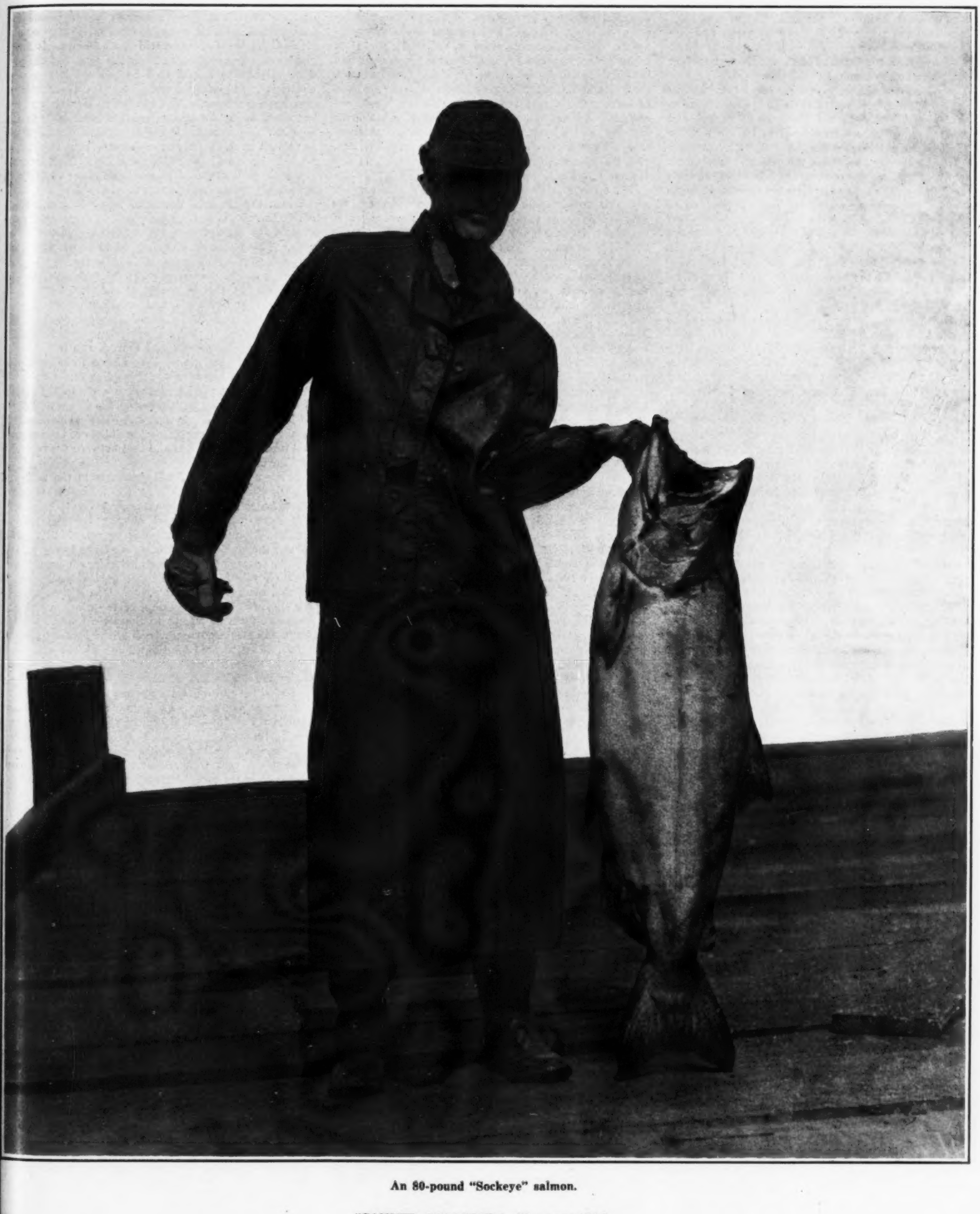


An 80-pound "Sockeye" salmon.

"CANNED GOLDFISH."—[See page 276.]

The Principles of Biochemistry*

Their Application in the Study of Colloidal Minerals and Their Resulting Use in Medicine

By John A. Handy, Ph.C., B.S., Phar.M.

Who knows what Life in all its phases really is? We note its characteristic manifestations in the mineral kingdom, in the animal kingdom, and in the human kingdom. We are even intuitively conscious of a still higher form of life. What are the various elements in nature which enter into our physical conception of Life? The intellectual giants of Science, Philosophy and Religion in all ages have grappled with the same problem, and yet, with all our heritage of knowledge and wisdom the problem awaits a complete solution.

The phenomena of spontaneous movement, irritability or response to stimuli, assimilation and disassimilation (metabolism)[1], and even the processes of growth and reproduction, which are considered to be the peculiar characteristics of living matter, have all been singularly imitated by artificial means in the scientific laboratory.

However similar some of these artificial manifestations of living phenomena may be, they are not actual duplications of life or living material. There appears to be some element or principle present in the living protoplasm of nature which is not present in the artificial protoplasm of the laboratory. All of these experiments point to the fact that the chemistry and physics of the living organism are essentially the chemistry and physics of nitrogenous colloids—true organic or vitochemical compounds.

A vitochemical substance or preparation is one which consists of a colloidal mineral element or compound chemically associated with native organic substances—proteins, fats, carbohydrates, etc.—in that form of refinement of particle and degree of activity as most nearly approaches the form and combination of true organic vegetable or animal tissues. Prof. E. A. Schäfer, in his recent article on "The Nature, Origin, and Maintenance of Life," expresses the advanced views of contemporary Physical Science on the chemical constitution of living substance, when he says: "Living substance or protoplasm always, in fact, takes the form of a colloidal solution. The elements composing living substance are few in number. Those which are constantly present are carbon, hydrogen, oxygen, and nitrogen. With these both in nuclear matter and also, but to a less degree, in the more diffuse living material which we know as protoplasm, phosphorus is always associated. Moreover, a large proportion, rarely less than 70 per cent., of water appears essential for any manifestation of life, although not in all cases necessary for its continuance, since organisms are known which will bear the loss of the greater part if not the whole of the water they contain without permanent impairment of their vitality. The presence of certain inorganic salts is no less essential, chief among them being chloride of sodium and salts of calcium magnesium, potassium, and iron. *The combination of these elements into a colloidal compound represents the chemical basis of life*, and when the chemist succeeds in building up this compound, it will without doubt be found to exhibit the phenomena which we are in the habit of associating with the term of life."

A rational explanation and understanding of these biochemical elements and principles necessitates a brief consideration of Nature as a whole as a basis for the larger conception of a chemistry which deals with Life itself. Nature embraces certain fundamentals which are classified as ultimates, and which appear to be universal in time and space. These ultimates are five in number. Three of these—Matter (the universal property of Nature), Energy (the universal mode of Nature), and Life (the universal element of Nature)—command our especial attention at this time. A careful study of these universals reveals another stupendous fact, viz., that our whole system of evolutionary growth and development is brought about by the operation of a great fundamental law or principle of Nature acting through and upon these five ultimates.

This great fundamental principle is known to chemists as the Law of Chemical Affinity, and is refining in principle, evolutionary in growth, harmonic in operation, vibratory in activity, and constructive in effect. In short, it is Nature's universal formula for evolution, which refines matter, increases its vibratory activity, and generates life.

The biochemist, from a careful study of the broad field of Natural Science, takes the data of the chemist and physicist, of the anatomist and physiologist and pathologist, out of which he constructs an imagery of his own, dealing not with atoms and molecules as such, but with the conceptions of the physical and chemical nature of protoplasm, in the processes of reaction-velocity, catalysis and ferment activity, equilibrium, viscosity, osmotic pressure, colloidal mutability, allotropic transmutations, and electrolytic dissociation in vegetable and animal tissues. He must first, however, recognize and study the operations and manifestations of certain fundamental governing elements which coordinate the multiple phases of mineral and cellular activity, and appear to magnetize, vitalize, animate, and vivify respectively the four great kingdoms of nature, viz., the Mineral, the Vegetable, the Animal, and the Human kingdoms.

These governing elements, which are four in number and also appear to be universal in time and space, we may designate as the Life Elements. The science of chemistry is principally concerned with only two of these life elements, which are defined as follows: (1) Electromagnetism; (2) the vitochemical life element. It appears that one or more of the four life elements magnetizes, vivifies, vitalizes, or animates all physical matter, including the mineral atom, the plant, the animal, and the man. It would seem, then, that what we know as magnetism in minerals, vitality in vegetation, and physical life in the animal and man, are, in fact, certain temporary relations established between physical material and the finer and more subtle life elements.

The withdrawal of the life elements in each kingdom appears to produce the same result, viz., devitalization and death. Physical matter is, therefore, negative to and subject to the more positive life elements. The principle of affinity or polar attraction appears to inhere in the vital elements themselves, and not in the solid particles of physical matter. Each life element is also assumed to display dual and yet differing powers and capacities of positive and receptive energy.

In the mineral kingdom the constructive and integrating principle of Nature operates through the electromagnetic life element alone.

In the vegetable kingdom the constructive, integrating principle of Nature operates through two life elements instead of one. That is to say, it operates through the electromagnetic and the vitochemical life elements. Of these two life elements the vitochemical is the dominating one in vegetable organic process. It controls those higher functions of Nature associated with the properties of organization, growth and reproduction. The entire plant kingdom is an expression of the vitochemical element in Nature.

The operation of the law of polarity through the life elements upon the individual units, whether between the mineral atoms or the vegetable cells, is a ceaseless effort to establish vibratory correspondence and an equilibrium of forces in a perfect union. The result of these ceaseless activities of the individual particles upon each other is a refinement of the atom in the compound.

There comes a time when a portion of the mineral substance is raised to certain ratios of correspondence with the vibratory action of the next higher element of vitochemical life, which appears to lie universally and coextensively in time and space with the lower element of electromagnetism. When the mineral atom has been thus raised it becomes susceptible to the essence of coordination of the higher life element. Impregnation occurs. The vitochemical life element is inducted into mineral substance and the mineral atom becomes a vegetable particle endowed with vitochemical or vegetable life. Is it not reasonable to suppose that by this evolutionary process, guided by Nature's constructive principle, all life is generated upon this planet?

If all inorganic chemical compounds are the offspring of the electromagnetic element in Nature, is it not reasonable to suppose that these potential electromagnetic energies may be liberated from substances under certain conditions of chemical activity, and that electricity is one of the manifestations of this most simple of life elements?

Again, consider the properties and activities of vegetable protoplasm with its combined potentialities of electromagnetism and vitochemical energies. Take for example one of the simplest forms of vegetable life—the yeast cell. This cell, microscopic in size and possessing the simplest anatomical structure, and consisting simply of a colloidal solution of mineral salts in true organic or vitochemical form, is capable of growth and reproduction, and of carrying out many complex reactions. The yeast cell is capable of elaborating certain nitrogenous colloids called enzymes or ferments which convert sugar into alcohol, carbonic acid and water. Under certain conditions the yeast cell converts sugar into glycogen, which it may store for a long time within itself, or which it may soon reconvert into sugar and then into alcohol. Under other conditions it may oxidize alcohol. It synthesizes protein and cellulose. It forms glycerine, succinic acid, and amyl alcohol. It may reduce sulphur to sulphureted hydrogen. It generates electricity. It performs, undoubtedly, a whole series of cleavages, syntheses, oxidations, and reductions, and yet, examined under the microscope, it appears fairly homogeneous. No structure is visible capable of explanation as to how, in this small space, so many processes can go on side by side in an orderly fashion without interfering with each other. This multiple phase activity is manifestly impossible in a test tube.

Much experimental data and many interesting and clever theories have been advanced to demonstrate and explain the multiple activities of the simplest of living cells. These studies have all led to one fundamental principle, viz., that *co-ordination* is the great characteristic of life. Anything which intermixes protoplasm and thus disturbs its phases of activity destroys co-ordination, and protoplasm dies. In other words, when the vitochemical life element escapes, co-ordination ceases, plasmolysis ensues, oxidation, hydrolysis, and the various other processes of the cell run riot, devitalization results, and we no longer have living material.

It is toward a clearer understanding and a scientific application of the vitochemical life element that the biochemist of today must direct all his efforts and apply all his knowledge of physical and chemical science if he would ever bridge over Nature's gulf between the mineral and the vegetable worlds and that between the vegetable and the animal worlds.

A simple experiment will demonstrate the action of the vitochemical life element by producing within a few minutes what looks like a profuse vegetable growth. The experiment is carried out by introducing into a colloidal solution of sodium silicate (sp. gr. 118) crystals (about the size of a pea) of salts of the heavy metals, such as ferric chloride, ferrous chloride, copper chloride, uranium nitrate, silver nitrate, gold chloride, cobalt nitrate, manganese sulphate, etc. One is then witnessing the actual transformation of the coarse crystalline inorganic form of matter to the more refined colloidal form. Similar results may be obtained by dropping into a fairly concentrated solution of potassium ferrocyanide little pills (size of a pea) made of copper sulphate or other heavy metal salts, and sugars.

A study of protoplasm leads one to conclude that the phenomena of "organic life" appear to be the manifestations of the universal vitochemical life element through colloidal matter.

Hermann Hille has recently claimed to have demonstrated the fact that colloidal minerals are Nature's bridge from the mineral kingdom to the vegetable kingdom. He is the first to make a successful application of the vitochemical principle in the study of colloids and the preparation of minerals and mineral salts in "true organic" form. He is the first to point out and demonstrate that true organic substances are colloidal forms of matter, and are, therefore, allotropic modifications of inorganic substances—the crystalline forms of matter.

All physical nature is divided into the inorganic world of mineral matter and the organic world of vegetable and animal matter. Chemical analysis reveals the fact that the inorganic world is composed of the same elements that are found in the organic world. From the viewpoint of chemistry of today, therefore, the difference between organic and inorganic is not chemical in character, but a difference in structure only. The characteristic structure of the inorganic world is rigid and crystalline; its basis is the crystal. The characteristic structure of the organic world is plastic or colloidal; its basis is the cell. Thomas Graham classified inorganic matter as "crystalloid" and organic matter as "colloid." Organic substance (the colloidal form of matter), therefore, is an allotropic[2] modification of inorganic substance, the crystalline form of matter.

For example: Diamond and charcoal and the carbon of protoplasm, in a purely chemical sense, are the same, so far as we know. They are allotropic forms of the element carbon. The diamond is crystalline or inorganic;

*Extracts from a paper read before the Section on Pharmacology and Therapeutics of the American Medical Association. Reprinted from the *Medical Record*.

[1] The terms "assimilation" and "disassimilation" express the physical and chemical changes which occur within protoplasm as the result of the intake of nutrient material from the circumambient medium and its ultimate transformation into waste products which are passed out again into that medium; the whole cycle of these changes being embraced under the term "metabolism."

[2] By allotropy is understood the property which certain chemical elements have of existing in two or more distinct forms, each having certain characteristics peculiar to itself.

charcoal is an amorphous or semiorganic form of carbon, whereas the carbon in protoplasm is the true organic or cellular modification.

The results already obtained in colloidal chemistry make it safe to proclaim that every known substance can be raised from the crystalline to the more refined colloidal form.

Experiments with colloidal metals by Fillipi, Henri, Stodel, Ascoli, Izar, and others demonstrate that colloidal metals are as powerful in their bactericidal action as their inorganic salts, but very much less poisonous, if at all, in their effects upon ferments like pepsin, trypsin, pancreatin, etc. The effect of colloidal metals upon the enzymes of autolysis, or autodigestion has been found to be accelerating and beneficent. In fact, colloidal metals in themselves possess ferment action which can be retarded or entirely annihilated by traces of poisons like hydrocyanic acid, bichloride and cyanide of mercury, arsenous acid, carbon monoxide, etc. In other words, colloidal metals can be poisoned like other organized substances.

Not only the metals and other elements can be produced in the colloidal form, but their salts and other combinations as well. It is invariably found that the colloidal form is very much less poisonous and injurious than the crystalline form. For example: Colloidal copper arsenate is said to be one million times less poisonous than crystalline copper arsenate.

All of our wholesome, natural food is colloidal in its nature. Milk, butter, cheese, eggs, meat, vegetables, fruits, honey, etc., are all colloids—not only their protein, carbohydrate, and fat constituents, but also their mineral bodies in true organic or vitochemical form, which have been almost totally ignored in medicine and dietetics, appear to be of such vital importance that "not one of the vital processes of the human organism is possible without them." Progressive physicians are beginning to recognize that the mineral salts of our food, which were formerly considered more or less unimportant, or secondary in importance to the three main classes—proteins, carbohydrates, and fats—are of the first importance.

The natural mineral salts are not only of the first importance as tissue foods, but are also the chief waste eliminators in human metabolism. To get some idea of the promptness with which the body acts in the elimination of waste matter and to emphasize the importance of taking our mineral salts in true organic form, wherein they will act as foods rather than as irritants to protoplasm, try the following experiment: Eat a tablet of lithium citrate. Then take a clean platinum wire, hold it in a colorless flame of a bunsen burner and note that it gives no coloration to the flame. Now pass the wire along the skin of the forehead, or after rinsing the hand in distilled water draw the wire across the palm and again hold it to the colorless bunsen flame. Note the beautiful yellow color due to the presence of the sodium. Next take the blue glass and observe the yellow flame through this; the cobalt glass absorbs the yellow sodium rays and the lilac flame of potassium now shows. About a half hour after taking the lithia tablet make the same test as above with a clean platinum wire. The vivid red flame of lithium is now obtained. In one short half hour the lithium entering at the mouth has been absorbed into the blood and carried to all parts of the body and is being excreted through the skin.

Is it not true that if the physician can control nutrition he can control disease? If it is true, and I believe it is, then a thorough knowledge of the mineral salts in true organic or vitochemical form—both in their native occurence in our natural foods and in their synthetic forms—is necessary

An interesting conclusion in connection with the relative value and importance of vegetable and animal foods in the human economy may be drawn from the following facts: As a general rule the chemical changes in plants are progressive or constructive; in an animal, regressive or destructive. Some cleavages are brought about in plants and some syntheses are carried on in animals. Animals take up the organic vegetable substances which have been synthesized by plants, assimilate them and excrete waste products which are identical or nearly so, with those substances serving as food for plants. Animal food will, therefore, contain its own waste which will be so much extra inert and poisonous material for the human organism to eliminate. In the case of plant foods we do not have this extra waste material to take care of.

The facts of modern science, with their references, bearing upon the important subject of mineral starvation and disease, have been comprehensively reviewed in a recent article by Hermann Hille in the *Medical Record* of June 15, 1912. Dr. Hille draws the following significant conclusions: First, that the primary cause of disease, from a purely physical viewpoint, is chiefly mineral starvation, and, second, that minerals in inorganic form cannot be utilized by the human organism as directly and effectually as can true organic minerals.

Dr. H. Packard, in a recent article on "The possible Factor in the Causation of Cancer," in the February issue of *Surgery, Gynecology and Obstetrics*, writes as follows: "In view of the apparently well established fact that in the vegetable world an adequate supply of the earth salts—phosphorus, potassium, iron, manganese, silica, sodium, etc.—act as a distinct deterrent on parasitic life, and make for vigorous, virile, disease-resisting, healthy life, may we not assume as much for the animal world?

The possibilities of the application of colloidal chemistry in medicine are suggested, not only by some of the colloidal preparations mentioned here, but also by the results obtained by Prof. Martin H. Fisher, whose recent publications, "The Oedema" and "Nephritis" and their subsequent discussions by William J. Gies and others are of value and interest to every thinking and progressive physician.

A clearer understanding of colloids and a more intimate knowledge of the facts of colloidal chemistry and of the vital importance of the colloidal forms of matter for the manifestations of organic life and in the elimination of pathological conditions will not only accomplish a much needed simplification of materia medica, but will also facilitate a rational understanding of the primary causes of disease and will thereby elevate the uncertain art of healing to the dignity of an exact science. It would enable the physician to know why a remedy ought to be colloidal or organic, and why crystalline or inorganic remedies are foreign matter to the human organism and act as poisons and irritants instead of foods.

A careful study of the vitochemical principle in Nature, and its application in biochemical research, will revolutionize our chemistry of today and give us a new materia medica for the future.

The Sense of Taste

By Alfred J. Lotka

The sense of taste and smell are in a class by themselves and differ in certain respects from the other special senses. They have been described as the chemical senses; and since chemical action can take place only between substances in actual contact, we can become aware of the smell or taste of a given material only by actual contact with it or its vapors. This places a certain restriction upon the scope of these senses, as compared for example with sight and hearing. In man, at any rate, the chemical senses are not developed to the same degree of refinement as sight and hearing. Nevertheless they fulfill very important functions, their primary purpose being, no doubt, to enable the individual to exercise the proper judgment in the selection of his food. This is indicated by the location of the organs of smell and taste in and near the mouth. In the case of animals the senses of taste and smell do very efficiently fulfill this function; in fact, the presumption is that animals have no other means of distinguishing healthy from injurious or poisonous materials for food. In the case of man, the same reliance cannot be placed upon the sense of taste, as some poisons have a pleasant taste, and some substances which are more or less harmless have a disagreeable taste. Aside from the perfectly normal discrepancies between our likes and dislikes in the matter of taste, and the things that are good for us or otherwise, individual persons may be subject to various peculiar abnormal vagaries of the sense of taste. The simplest of these is a more or less complete "taste blindness," which accompanies various diseased conditions ranging in seriousness from a common cold to incurable affections of the central nervous system. In the case of general paralysis it is especially the sense for saltiness that is lost. People subject to epileptic fits almost invariably lose the sense for sweetness, often also for saltiness, but usually not that for bitterness, at the time of one of their attacks. Sometimes it is only one-half—usually the left—of the mouth and tongue that loses its sensitiveness. Persecution maniacs who are in fear of being poisoned often have an exaggerated sense of taste.

Occasionally a peculiar case is found in which different tastes are confused; the patient for example, asserts that a bitter substance tastes salty to him. In the case of neuropathic persons, that is to say, persons of somewhat unstable mental balance, certain tastes are sometimes associated with color sensations. A temporary loss of the sense of taste can be produced at will by painting the tongue with certain drugs. Cocaine, if applied somewhat liberally, causes local anesthesia: in mild applications it merely deadens the sense for bitterness. Some insane persons are subject to "taste hallucinations." Perversions of the taste, more or less morbid in character, are observed in hysterical and other persons. There is a certain disease in which the patient will eat all sorts of unsavory and even disgusting things. Without going to such lengths as this, many people have a preference for meat, especially venison, which has been allowed to undergo partial putrefaction. Some savages do not draw the line at a *partial* putrefaction, and show undisguised signs of great gusto in devouring materials which would turn the civilized man sick.

A peculiar and interesting phenomenon is that of *inversion* or *contrast* effects of the sense of taste. After partaking of something very salty or very bitter, pure water tastes sweet. This perhaps is not very surprising, but a one per cent solution of potassium chlorate, which has itself very little taste, causes water taken into the mouth after such solution to taste intensely sweet. If the mouth is rinsed with copper sulfate or potassium permanganate solution, cigar smoke acquires a repulsively sweet taste. A somewhat similar observation is recorded by Gattermann, who states that if the air contains mere traces of prussic acid, cigar smoke acquires a peculiar taste, which thus furnishes an efficient alarm signal.

Substances possessing a marked flavor are of great importance in daily life, perhaps none more so than salt, sugar, and vinegar. As regards the first of these, it is absolutely indispensable and there is no substitute for it. The place of vinegar can in a measure be taken by other acids, such as for instance, lemon juice. Sugar is not one single substance, but is the name given to an entire class of more or less closely related compounds containing carbon, hydrogen and oxygen. Sugar fulfills a double function, being both a food in itself, and, on account of its pleasant taste, an appetizer.

In the diseased condition known as diabetes, sugar becomes highly injurious to the patient, who is thus condemned to a rather monotonous diet. Fortunately modern chemistry knows several substitutes for sugar, notably saccharin, which not only equals but vastly surpasses sugar for sweetening power, while being at the same time quite non-poisonous, to judge by experiments upon man and animals. Thus, for example, one person in nine days consumed 520 grams of the sodium salt of saccharin, a quantity which ordinarily would be sufficient for four or five years' needs, and showed no ill effects whatever. It is sometimes stated that animals will not eat foods sweetened with saccharin. This does not seem to be true, except perhaps for ants and bees, who require sugar, not on account of its sweetness, but on account of its food qualities. Saccharin has no value as a food, and moreover, it is so intensely sweet that the quantities ordinarily taken with the food would be negligible even if it had a food value.

The chemistry of flavoring material, and the study of chemical constitution in relation to the taste of various substances has grown to large dimensions, yet until recently no one collected work of reference on the subject was available. This gap has just been filled by a book from the pen of Dr. G. Cohn, on Organic Flavoring Materials, published in Berlin by F. Siemenroth, from the introduction of which many of the data given above are taken. The bulk of the book is highly technical and gives a mass of data regarding the taste of a large number of organic substances. For those working in this field, whether from purely scientific interest or for the sake of applications to practical ends, this collection should prove very valuable.

We have here culled out points of interest to the general reader, and will close with one more observation of this character taken from the chapter of Psychology of Taste. It is rather surprising to read that girls have a more sensitive taste for bitter and boys for sweet. Their taste for saltiness is equally sensitive. Adult woman has a more highly developed sense of taste than man for sweet, bitter and sour. For salty materials there is not much difference, if anything man is a little more sensitive than woman. A facetious person might be tempted to say that this must be taken with a grain of salt.

A New Method of Tapping Blast Furnaces

The old method of tapping blast furnaces was by means of a long, pointed steel bar, and not only was the operation dangerous, but it was also a slow one, and it was superseded not long ago by a hand drill. Recently an electric drill has been introduced which is supported by a long handle, and is capable of making a 2½-inch hole. The operating switch is placed in the end of the handle and is so designed that the power is automatically cut off as soon as the operator lets go the handle. It is said that a furnace can be tapped with this machine in less than five minutes, the actual drilling time not exceeding two minutes. The electric drill is withdrawn when within an inch or so of the iron, the final tap being made, as usual, with a long bar of steel. Drills of this type are being used by the Carnegie Steel Company, Pittsburgh, at its various blast furnaces. The drill shanks are about ten feet in length, about three feet of which is twisted. The drill is 2½ inches in diameter. At the Edgar Thomson plant at Pittsburgh the drill is hung on a special crane, which is so arranged that danger of accident to the operator is obviated.

"Canned Goldfish"

The Rich Harvest of the North Pacific Coast

By M. J. Herbert

Soldiers during the Spanish-American war ate so much canned salmon that they grew tired of it, and in a spirit of derision named it "canned goldfish," from the color of the meat. To the northwest section of this country and Alaska it is indeed "canned goldfish." And a fish cannery is far better than a gold mine.

Three million and a half cases of salmon, valued at more than sixteen millions of dollars, were taken from a strip of water reaching from the salmon banks of Puget Sound to the mouth of the Frazer River, a total length of forty-five miles, from July 15th to September 15th, last year. Think of it, eight millions a month garnered from "Father Neptune" without as much as by your leave! If this were a placer strike in Alaska newspapers from coast to coast would have scare headlines a yard long, and the news would relegate war scares to the second page. As it was, the fact was hardly commented upon, even by the local papers.

The value of the salmon canned on the Pacific coast is exceeded by one industry only—the lumber business. Yet far more money is spent in the process of production in the salmon canning industry than in the lumber. The opinion prevails in some quarters that this industry is one which thrives on the destruction of the raw product which it uses and requires but little outside the raw product for its maintenance.

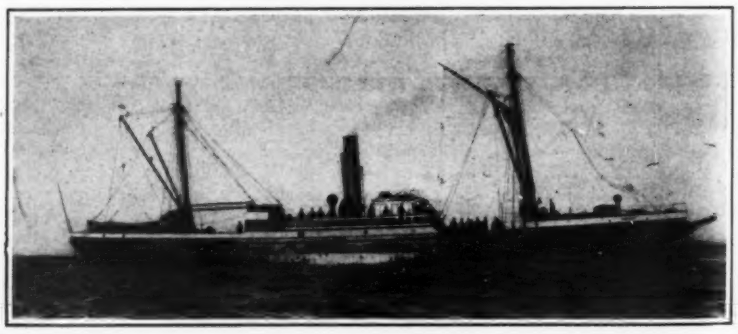
Thirty million dollars is spent annually in putting up salmon pack, labor taking the lion's share, amounting to six and a half million, the fish about six million, the balance of this princely sum being eaten up by miscellaneous materials. The value of last year's pack was over thirty-seven million dollars, and this does not include the fish sold fresh at local markets.

The salmon are caught by seines, traps, or fishwheels in the rivers or sounds, on the way to the spawning grounds after they leave the sea. As soon as caught they are hurried to the canneries as rapidly as possible, where they are unloaded on the docks by means of elevators. The dressing or "butchering," as it is called, is done speedily, mostly by machinery. The head and tails are sawed off on a band saw, where formerly they were cut off by a cleaver, in the hands of a Chinaman. The fish is then fed, tail first, into the "chink," which is the cleaning machine that displaced the Chinaman as a cannery laborer a number of years ago. By one revolution of the wheel the fins are removed, the body split open, the viscera torn out, the interior wall scrubbed by revolving brushes, and the dressed fish delivered into a tank of water. It is then placed upon a specially slitted elevator which feeds it into a series of revolving knives, or disks, which cut it into lengths

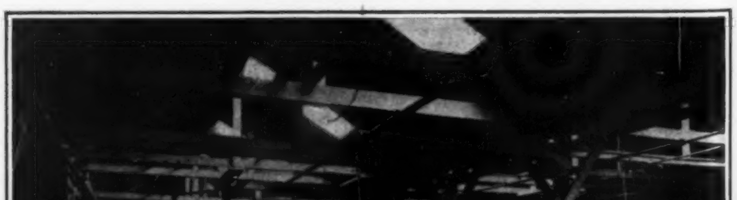
Cutting machine and mechanical "chink."

Drying room, containing 4,000,000 cans.

Unloading fish to an elevator at the packing house.



U. S. Revenue cutter Grant, sold and converted into a fishing steamer. Wrecked on Alaska coast, 1912.



Labeling and boxing the cans.

Gathering the salmon catch in a fish trap.

It is estimated that the catch of such a trap is 2,500 salmon every twenty-four hours, averaging eight pounds. During the height of the salmon season these fish sell for five cents a pound at the trap.

corresponding to the height of the can it is intended for. There are a variety of lengths used, only three of which are standard, commercially known as No. 1 tall, No. 1 flat, and the half pound cans.

The grading of the fish is done on the basis of solid and less desirable cuts. Cans are generally filled by machinery, but a few choice parts are packed by hand. The cans are boiled in retorts at a temperature of about 250 deg. Fahr. for two hours, then taken out, dipped in lye to take the grease off the cans, dried, labeled and packed, forty-eight tins to a box.

The salmon canner is a real Santa Claus in a way, his operations eventually playing an important part in gladdening the hearts of hundreds of thousands of small boys the world over, for the ranks of the armies of brave tin soldiers which march annually from the toy factories of Germany, to capture the heart of the war-loving boy, are replenished each year by the salmon cans of the Pacific coast. The scraps and odd pieces of tin are carefully saved, baled, and exported to Germany, where they enter into the composition of the doughty red and blue warriors who wage war so relentlessly upon one another, on the world's nursery floors. But real war has now suspended this industry.

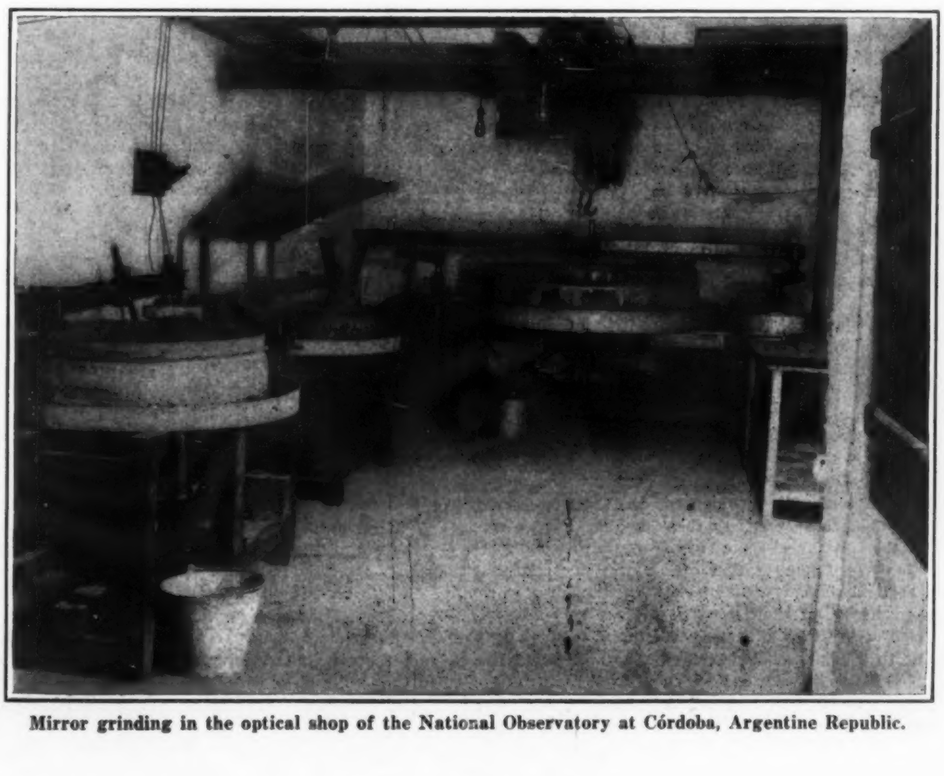
Optical Shop of the National Observatory of the Argentine Republic

By J. O. Mulvey

The optical shop was established in 1913, chiefly for the construction of the mirrors required for the reflecting telescope of 1½ meters aperture provided by the government for the Córdoba Observatory. In addition to this, we are also making the mirrors for a reflecting telescope of 30 inches aperture and a 36-inch test plane for testing the parabolic mirrors. In order to have as little interference as possible a machine was made for each of these, and the illustration shows the three machines in the position they occupy.

The optical shop is in the basement of one of the observatory buildings where temperature conditions are very even and changes take place slowly, the observed difference of temperature between extreme winter and summer being only 11 deg. Cent., and between day and night is inappreciable. A tunnel extending from one end of the shop gives a length of 65 feet for testing.

Each of the machines is provided with an overhead trolley and hoist for handling the glass disks and heavy cast iron grinding tools. No difficulty was experienced in making cast iron grinding tools for the 61-inch mirror of sufficient stiffness and still light enough not to require counterbalancing. The three machines are the same in principle, the only difference being in some of the details on account of the difference in size of the work they are to do. Independent motor drive is used. The problem of reducing the speed of the motor from 1,800 revolutions to 25 and 27 revolutions per minute (the speeds of the driving arm and turntable shafts in the large machine) is met through spiral or worm gearing. Gearing of this class is often looked upon with suspicion by mechanics, but if properly made and applied is very efficient, a one horse-power motor supplying ample power for our large machine. All upright spindles have ball end thrusts. These machines are very steady and smooth in operation and are under perfect control of the op-



Mirror grinding in the optical shop of the National Observatory at Córdoba, Argentine Republic.

erator. They are compact and take up very little room considering the size work they are doing.

The preliminary testing of the 36-inch flat is being done without removing the work from the machine. At the end of the day's work the polishing tool is removed and the disk cleaned, and a 12-inch test plane placed upon it and left over night for the temperature to even up. In the morning the work is examined by a mercury arc light, the interference bands showing the high or low places, after which the tool is trimmed accordingly and work resumed. The final testing will have to be done by setting up in connection with a perfected spherical surface, and tested at the center of curvature by an artificial star. The 61-inch disk will have to be perfected for this and afterwards parabolized. The artificial star apparatus has a portable arc lamp for an illuminator. This gives a very brilliant star and permits the use of a very small aperture, enabling the operator to see very small irregularities of figure. The perfecting of figure on mirrors of this class has to be carried to a very fine degree of accuracy, the demand being constantly for something better, and the optician's skill is taxed to its limit. The ability of an optician lies largely in his skill of testing.

At the end of the tunnel, away from the grinding machines, is the dividing engine for ruling diffraction gratings. This machine has been perfected to the point where it shows no appreciable errors by the crossed line ruling test as used by Rowland. On account of the great amount of other work on hand, but little regular time has been given to this machine, most of the work being done on the holidays, of which there are many here. It is hoped to get gratings of about 120,000 lines resolving power from this machine, providing very valuable instruments.

Thorough ventilation is given the optical shop by forcing air slowly through a large underground passage 70 feet long. This gives the dust a chance to settle and fresh air enters at room temperature.

The writer divides his time between the optical shop and construction work, and as there is no assistant on the optical work, progress is more slow than would otherwise be the case. The smaller disks have advanced to the point of testing, but the large disk is still in the roughing stage. The large disk will clear up 61 inches in diameter, is 10 inches thick, and weighs 1 ton. The 30-inch telescope will be used at the Córdoba Observatory, but the large telescope will be placed in the mountains a few miles west of Córdoba.

The Value of Radium in Surgery

An Estimate Based on Our Present Knowledge

By Robert Abbe, M.D., Senior Surgeon to St. Luke's Hospital, New York

Truth is revealed slowly in science—as words spell themselves out letter by letter. The *whole* truth about radium will be written years hence, for we are in the first decade and its importance still grows. Ten years ago Prof. Rutherford, who is easily the first authority to-day on the subject, said to me that the physicist then knew about all that was likely to be known about radium, and it was the work of the medical profession to see what it would do in their hands. Since then he has issued a new edition of his great work every year or so, old ideas being obsolete, and still finds that it is the newest wonder in science. Is it any marvel that its usefulness cannot be estimated by our present knowledge of its ability to cure? The only regret is that the profession and public have been expecting too much. People who expect too much are *never* happy when they get less than they expect.

We are dealing with a wonder-working mineral unlike any other agent in our hands. While it resembles the energy of the Roentgen ray, it is unlike it in many ways. The output of a small bit of radium powder is a composite force largely electrical, but unlike electricity in any form heretofore known to professional work, it is associated with the extraordinary discharge of infinitely numerous streams of particles each bearing its charge of electricity, some positive, some negative, resulting from the explosions of atoms with a force driving them into tissues with the speed of light. Into nature's rocks, by the most artful exhibition of scientific detective work, Madame Curie pursued this unknown substance and dragged it forth, a little giant in power, to reveal the hidden mysteries of physical force and touch human interests in the control of some diseases. In itself radium illustrates in concentrated form the universal process of change and decay of matter. Its enormous energy is like incorporated life, and its electrons like imprisoned life released.

The first surprise we all felt at seeing a photograph by the Roentgen ray through an opaque body is eclipsed by the photograph made with the same marvelous penetrating power of a tiny pinch of radium confined in a glass tube, photographing through the human body, or a granite boulder, or some several inches of steel. As it penetrates stone or steel, it moves in undeviating lines. Nothing can deflect its direct movement, or resist the destructive power of its impact. Yet it carries into the tissues also a material force not *destructive*, but a subtle power to help—a *constructive* force—which the keenest study has not yet analyzed or harnessed. This is a *stimulating* force recognized first in its effect on plant life, and later brought into use to explain some of the phenomena of its influence on tumors.

At this point all argument has to give way to observation. Until we know why cells grow, what innate power resides in living tissue which compels growth and orderly change in living cells, and until we know why the disorderly and exaggerated overgrowth of cells forms life-destroying tumors, we will not be likely to know what the influence is which is shot into the cells by the atoms of radium which reduces them to orderly growth. One observer may theorize about the known bactericidal power of some rays from radium being responsible for the alteration of tumors; another, that the chemical changes brought about in the delicate protoplasm may alter their growth; another may advance an hypothesis that the even course of cell growth may be due to a balance between a positive and a negative electric charge in each cell which controls its acts, for they seem to respond to electrical affinities, and that the loss of one might permit an unbalanced and inordinate overgrowth, which a due supply of beta rays of radium each carrying a negative charge of electricity might correct. In any case the sophism of Huxley that "theories help us to bear our ignorance of facts" reminds us that one must revert to the habit of observation for the most part if one would make well grounded advances. So let us now drop all blinding sense of wonderment or misleading or distracting theories and argue on facts alone.

Many have lost sight of the first uncontroverted claims of the action of radium in retarding seed growth, or in repressing animal life, as shown by the prolongation of the worm stage of radiumized worms while the unradiumized brother and sister worms passed into the chrysalis and succeeding beetle stage, completing the cycle by laying eggs which become worms again, while the radiumized worm remain unchanged—a sort of Methuselah; or, again, the irritative spinal meningitis in mice exposed to radium; or, the disappearance of superficial epitheliomas of the face under radium. Were that all that could be claimed it would be a small contribution indeed. Each year, however, has added something to the credit of its utility. Of this it may well be said that, considering the small amount in existence and the few observers, it is amazing that so much can already be claimed. It is as if a hundred scalpels only were in existence in the world instead of a million for ingenious and experienced men to use.

It is not yet known how best to use radium, whether in strong form or dilute, whether in naked form on a varnished surface or confined behind thin or thick metal filters, to hold back some classes of rays, or in the form of emanations. In view then of the confusion of method and the long time needed to attain permanent results by the few cautious observers, it is no wonder that slow progress is being made. Its evolution is not unlike that of the flying machine, only just now beginning to be practically useful.

Perhaps the first unqualified proof of its conquest of disease was in its dissipating the epithelial cancers of the face. Grant that it followed the same efficient action of Roentgen rays demonstrated to the credit of that marvel; grant that surgery had for generations been able to treat successfully these same small growths by cutting them out or burning them out by cautery or chemicals! By these means we have formerly cured the patient—and we still do so—but we never cured the disease—we only removed it. Now comes a new and subtle power which cures the disease, drives back into orderly life the disorderly cells constituting a tumor. We hold our breath in surprise—and rightly so!

A natural question now arises. Is there here a specific action? Is there a selective action against the component cells of a tumor discriminating in favor of those of healthy growth? We answer, yes, and offer proof by several facts. First, consider myeloid sarcomas. A myeloid sarcoma is an overgrowth of the myeloblasts of the bone marrow. As they increase enormously they destroy the calcific bone by pressure or absorption, until all semblance of the bone is gone and is replaced by a pultaceous mass of soft tumor. In the near future the life of the patient may be sacrificed. During the growth of the tumor a correct dose of radium is given, and the cells not only cease growing but retrograde, and permit a reformation of the bone with its original structure and form. We have to assume that the enormous production of marrow cells has been reduced by atrophy and absorption during the cure, or that out of the riotous overgrowth of new weak cells the primitive cells have reassembled and returned to their normal life work. That certainly seems like a selective action against weak cells. Why has the vicious growing tumor halted and begun to retrograde immediately upon the application of a shower of radium rays? All that has been done has been to use beta rays, of which we know little except that each atom carries a charge of negative electricity, and gamma rays with no electrical charge, but a wave stimulation exceeding the speed of light. The effect is not transient but lasting.

The first startling case I had was of a patient part of whose lower jaw was destroyed by a pure myeloid tumor in which the teeth were set as if in jelly. Radium rapidly reduced the mass until gritty bone began to form and the entire jaw was re-established in shape and structure, with teeth solidly embedded, and this has remained as perfect as a normal jaw for ten years. This type of destructive tumor seems to be uniformly and quickly cured by radium. Ten cases have demonstrated this in my hands, some in the upper or lower jaw, others in the long bones. This I would call a specific act of a certain influence discriminating against disordered cell growth, and sparing healthy cells scattered throughout the tumor tissue.

Scores of similar effects could be quoted, but I will speak of only three others. The first was of a man on whose lower eyelid grew a tumor which in a year occupied more than half its breadth, pushed the lid from the eyeball and grew upward from the lid and downward on the cheek, a large purple tumor pronounced sarcoma by microscopic study. It was given expert Roentgen ray treatment twenty times with no benefit. After four hours of radium from a small tube laid upon it, it melted away day by day and was gone in eight weeks. From year to year for eight years I asked many medical men to say on which lid the growth had been. The eyelid had been entirely ungulfed by the disease, but out of the mass there were reassembled the original cells of the skin, of the sharp edges of the lid, of the hair bulbs and follicles, so that hairs grew again on the restored lid. Repeated examination of the microscope slides has led to dispute as to whether to class it epithelioma or sarcoma. Clinically it did not resemble epithelioma. In either case the radium acted as a specific cure.

Again, I ask you to consider a case of the type of round-celled sarcoma of the parietal bone of the skull. During one year the bone had been eaten away and replaced by a tumor of the area of one's palm, resting on the dura and lifting the scalp two inches from it. A section removed for examination showed a round-celled sarcoma. A silver tube with one hundred milligrammes of radium was inserted through it in two places and left eight hours in each. The tumor melted away until in three months it was gone, all but the thickness of blotting which shows a remnant of the same cells, entirely inert, in the fibrous stroma.

Finally, as showing a definite specific and selective action, one sees a papilloma in any part of the body disappear uniformly after thirty minutes of radium influence. This I have verified more than a hundred times. But the special point I would emphasize is the fact that where, as in the larynx, the vocal cords are buried in masses of papilloma filling the laryngeal space, the tumors disappear and leave normal glistening white vocal cords—the speaking and even fine singing power return. This proves, even more than gross appearance, that the delicate original tissue on which the tumor was built up, and from which it sprang, is not affected by the radium rays which caused the tumor to disappear. A dozen such cases in my hands have shown its infallible action.

One may also assert its specific action in all basal-celled epitheliomas. One may perhaps choose to call it a repressive action which causes every such tumor to retrograde immediately and permanently, in so far as a ten-year "cure" may be called permanent.

There is now accumulating also a series of cases of myoma, uterine fibroids, in which one or two irradiations of the tumor from the uterine cavity have been followed by progressive shrinkage year after year, until the growth was almost wholly gone, as if the disturbed cell reproduction had been corrected, quite like the types just mentioned.

It becomes us now to speak of some contrasting failures in a different type, the sarcoma which are composed of spindle cells sometimes mixed with a few large free cells, springing from and destroying bone very much like the myeloids, but not composed of or containing true myeloplaques. I have vainly endeavored to bring about a retrograde change in these tumors for many years, but have made no favorable impression on them, thus far, by radium. Beginning with a spindle-celled tumor of the temporal bone ten years ago, I have failed in this type, in several fair attempts in similar ones of the tibia, femur, and radius, and of some in the soft tissues, as in the popliteal space. I cannot even claim to have retarded or altered their growth; nor has the microscopic or gross appearance of the radiumized areas shown the specific effects of radium work. This is true also of some types of epithelioma of the skin, the squamous-celled type. Indeed, I have come to regard a resisting epithelial cancer as probably of that type before microscopic corroboration is given. The squamous-celled type are prone to invade the nearest lymphatic gland which the basal-celled tumor does not. By this the surgeon will be warned to resort quickly to thorough use of his keenest dissecting skill. Fortunately this type is relatively infrequent. It is evident then that discrimination in using radium is essential, most of all in the choice of cases, if we would bring this efficient agent into repute for its true value.

Yet there is a greater field of work, that of cancer, which must now be approached with all the skill and judgment of ripe experience, which has baffled surgeons of all times, and which is only now being touched by the new agents. With the preliminary facts which I have gone over, we are prepared to take the next step forward. First, I ask, has science revealed the nature of cancer in the virulent form which the public and all practitioners know it? It has not. We only know its gross and its microscopic appearance, its course, and its statistics. It has always been classed among malignant diseases, malignant in the sense that it is a life-destroying growth, composed of cells which in the beginning are a part of the normal cells of our body. In the judgment of pathologists a cancer of the uterine cervix begins as an epithelioma of the cervical mucous membrane; that of the stomach as an epithelioma of the follicles of the lining membrane; that of the breast as an epithelioma of the duct follicles; cancer of the rectum originates in the epithelial mucous gland structures.

If we could radiate the disease in its early groups, we could end it. Such facts exist. I have one patient whose cervix curettings showed early invasion of the submucous structure by proliferating epithelium, a typical early cancer in which radium treatment alone has given a cure of nine years. In only one other form of beginning cancer, that of the breast, where it begins as an epithelioma of the nipple, for which surgeons would always advise mammary amputation, have we an opportunity to test the value of radium in the early stage. In six such cases I have caused prompt disappearance of the growth and maintained subsequent health for several years.

During the years of trial I have necessarily tested radium in many of the massive and inoperable types of cancer, hard scirrhus breasts, encephaloid tumors, large fungating rectal cancers, and tongue cancers of all stages. It was right and just to the subject that these should be carefully subjected to test. I may also say that many terrible cases, from a surgical point of view wholly inoperable, have been offered to me by my surgical friends as a challenge which I have rarely refused. So that out of the mass of the history of ten years I can speak in general terms with some precision.

It is no small tribute to radium to say that in one-tenth of these active cancers a retardation can be seen and one third in time added to the expectation of life. The method of action of radium in cancer does not seem to me to be specific in the sense that it is in the diseases narrated earlier. Ten years ago I satisfied myself that radium kills the cancer cells in the groups nearby it, but within a limited radius, perhaps a quarter of an inch, and that to destroy large masses many tubes must be placed throughout the tumor. In such cases there was always tissue necrosis with more or less toxemia which always passed away safely. In the earliest days of its extreme use I occasionally observed a temperature of 103 degrees to 105 degrees, never serious for more than one to two days. This was followed by excellent repair. Perhaps I have never sufficiently followed up such cases by further attacks on the neighboring tissues, because they have been associated with pre-existing lymphatic disease, which made the task too hopeless. This method of attack is quite like that of Krönig, Bumm, Voight, and others who have given massive doses in uterine cancer to radiumize the gross mass and have felt that far better results were attained than by excision. Experimental work in this field is still being conducted, not without hope.

One practical, and demonstrated gain to surgery is seen in the principle enunciated by Wickham that if all the massive cancer cannot be removed, radium can be successfully applied to the thin shell of disease necessarily left, with the certainty that it will be destroyed. In one patient I was obliged to leave a thin layer of cancer grown to the wall of the carotid artery at its origin which, however, I radiumized *in situ*. Five years of perfect health have gone by with no recurrence. This principle of killing and safely leaving a small remnant of malignant tumor is of the greatest importance to surgery. It applies to every part of the body. Hence the postoperative use of radium promises to be a material advance.

But the most definitely good effect of radium work in these several cancers seems to follow the blocking of all the vessels nourishing the growth by a process of endarteritis. This irritation is of inestimable value in all radium work where high vascularity and active cell growth are present. Nothing so efficient in treating nevi, either capillary or angiomatous, is known to surgery. It effects a delicate blockading of vessels by endarteritis. Nor is this second to the beautiful results of radium in keloids. The true or the false keloid which no surgeon dares to touch with a knife, yields uniformly to the irradiation by radium which induces a soft fibrosis in the regular and active cellular structure, from which the accompanying itching and burning speedily vanish.

Not the least important rôle played by radium is in its special influence in causing retrograde metamorphoses in hypertrophic glandular structures like thyroids, lymph adenomas, lymphosarcomas, parotids, etc. This widens the important field of usefulness. I have treated half a hundred goiters of all varieties by radium alone, and have seen complete disappearance in a few and checked the growth in many. The ideal treatment for most troublesome cases is thyroidectomy. Nevertheless there is a large proportion of goiter patients either not greatly annoyed, or unfit for surgery, where radium is applicable.

Every physician feels the sense of helplessness when confronted by advanced cancer of the tongue. Even with thorough surgical extirpation early return of the disease is well-nigh certain. I have been impressed by the temporary improvement in many bad cases after using radium alone and have now adopted the combined extirpation followed by radium with a degree of hope, because of some cases of long freedom where the half tongue was first removed. Several years will be necessary to speak of cures.

It is difficult to know where to draw the pathological lines on tumors affected favorably by radium. It would almost seem as if all aberrant cell growths ought to be controlled, if some are, but certainly at present it seems that the myeloid and round-celled sarcomas and all tumors of lymphoid type yield wholly or in part and that basalcelled, but not squamous-celled growths are consistently curable. Tonsil sarcomas, some gliomas, pharyngeal neoplasms all yield some cases to the credit of radium. It is far too early to classify the types.

It is fair to say in conclusion that, stripped of all extravagant claims, radium is an asset of permanent value to surgery in the treatment of those diseases, some of them justly called malignant, which I have heretofore defined. In the graver form of cancer, which has so long baffled us all, some definite progress has been made as described, but hard research work must yet be done before someone puts his finger on the weak spot in its method of use.

Finally, let me add that one must pardon the occasional outburst of enthusiasm from those who are beginning the use of radium and are startled by its revelations. These are more than offset by the occasional tirades against it either by those who have never used it, or by those who have some other method to exploit. Both these are natural as they are negligible. They do not affect the real truth that as an agent for the relief of human suffering radium has proved to be a weapon of unique value in the surgeon's hands.

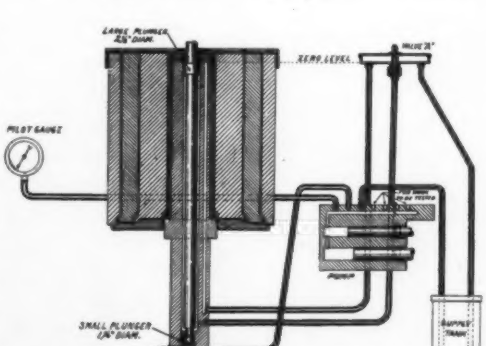
The Accurate Measurement of Hydraulic Pressures

The National Bureau of Standards at Washington, D. C., has recently installed an instrument for accurately measuring hydraulic pressures up to 4,000 pounds per square inch. This instrument is shown diagrammatically in the line drawing to illustrate the principle of action.

The principle of this machine is similar to that of the "Crosby" gage tester, that is, a known weight resting on liquid through a known diameter of plunger will produce a known pressure per square inch, neglecting the friction of the plunger in the cylinder. This friction is very greatly reduced by rotating the plunger, and in this instrument all danger of sticking under pressure is eliminated by the method described and patented by A. H. Emery several years ago of providing the plunger with a fine spiral groove.

This apparatus consists essentially of a cylinder and a piston rod provided with two plungers which fit this cylinder near its upper and lower ends. This rod carries a head, which in turn carries a tube to which is attached a platform which carries three annular weights, and by lowering this platform these weights can be successively placed on the tube and thus their weight transferred to the piston rod. The space around the piston rod, between the plungers, is connected with the leakage or "zero level" tank through a pipe provided with the valve *A*, and all leakage by the upper plunger also goes to this tank through the overflow pipe to the supply tank, and the oil is kept at a definite level in this tank and gives a uniform initial hydraulic pressure on the apparatus.

The hydraulic pressure is supplied by the two-plunger pump at the right, the plungers being driven by screws.



Diagrammatic view of instrument, illustrating the principle of action.

In use, if pressure less than 1,000 pounds per square inch is desired, the valve *B* is opened and the valve *A* is closed, in which case the hydraulic pressure operates on the whole area of the large plunger and the pressure obtained by letting on any of the weights is equivalent to the weight divided by the area of a 2½-inch circle, and in the apparatus as constructed the three weights shown each weigh 1,227.4 pounds and so give a pressure of exactly 250 pounds per square inch on the liquid, or a total of 750 pounds; the other 250 pounds being obtained by other means, as described later.

If higher pressure is desired, the valve *B* is closed and valve *A* opened, in which case the weights are carried entirely by the liquid under the smaller plunger, and as this plunger has exactly one half the diameter of the large plunger, the pressure will be exactly four times as much, or 1,000 pounds per square inch for each weight. To give subdivision of these loads and to be able to get a zero balance, the following arrangement is employed.

Two uprights at the left of the weights carry a lever through an "Emery" plate fulcrum, and the poise weights at the right can be lowered onto their platforms as desired, and their weight is carried to the plunger through a central stem, all the parts receiving the load through plate fulcrums. A slide weight gives still smaller increments of loads and the large weight balances the lever system and the piston rod, etc., so that when both the valves *A* and *B* are open the whole system is balanced with no load on the liquid.

By the use of these three sets of weights any pressure desired within the limit of the apparatus can be obtained to within one hundredth of a pound per square inch, and careful tests show that the apparatus is both accurate and sensitive to that amount.

Modern Research in the Metallurgy of Iron—II*

How Wonderful New Qualities and Properties Are Being Developed

By Allerton S. Cushman, Director, The Institute of Industrial Research, Washington, D. C.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2025, Page 259, October 24, 1914

Let us consider the names of some of the more prominent of these rare elements which research has introduced into the metallurgy of iron and steel, and review briefly what has been accomplished by their aid. Chromium, tungsten, vanadium, molybdenum, titanium, cobalt, tantalum—these rare elements have now their well-recognized place in the commercial exploitation of alloy steels. Steels containing, comparatively speaking, only very small quantities of these elements are made into tools which possess so-called self-hardening properties, and are known as "high-speed" tools. With such tools as these, enormous chips can be cut at high speed in heavy lathe and machine work. In many cases the tools can be used without oil and the chip and tool can safely be allowed to run almost red hot without damage to tool or work. Think of the economies in labor and time introduced by such a wonderful property as this. How can the influence thus exerted by these rare elements be explained? Becker tells us:[4]

"Carbon steel, as heretofore used in tools, no matter how well hardened, has not enough toughness and hardness to withstand the rubbing of the chip for any considerable length of time, even when not run fast enough to affect the temper. The tool therefore dulls; and this dulling proceeds in a sort of geometrical ratio as the cutting speed increases, being augmented by the drawing of the temper which accompanies rapid cutting. The speed in all metal-cutting operations has therefore had to be comparatively slow, no matter how powerful might be the machines in use. Thirty feet of chip per minute, as any machinist knows, has been considered rather good work; while 50 feet per minute has been very unusual. Under ordinary circumstances the management of a shop was pretty well satisfied if the machine tools could maintain an average speed of 20 to 25 feet per minute.

"Such deliberation, necessary though it has been, is depressing in this era. A creeping mass of metal turning leisurely round and round, or moving back and forth, as has been customary in the average shop, is quite out of harmony with the modern spirit of expedition and hurry. But while a few dreamed of the possibilities of cutting metal, some time in the future, with something of the vim with which wood can be cut; and while machines had been developed so tremendously as to leave scarcely anything to be desired in that respect, nevertheless the ultimate limit seemed to have been reached.

"But it had not."

* Read before the Franklin Institute and published in the *Journal* of the Institution.

[4] O. M. Becker, *loc. cit.*, p. 6.

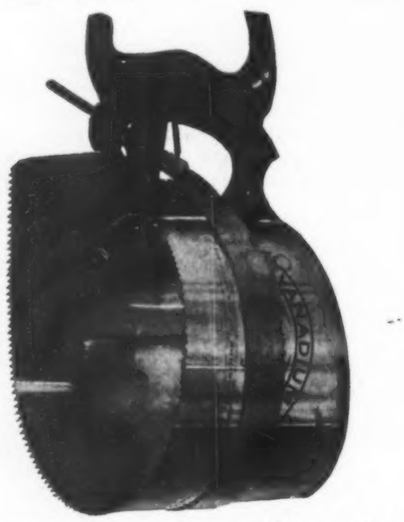


Fig. 8.—Vanadium steel saw which was kept coiled for four years and when unstrapped came out almost straight.

Fig. 5.—The vanadium mines at Minas Ragra, near the backbone of the Andes.

Fig. 6.—The Meigs Railroad leading up to the vanadium mines.

Fig. 14.—An ingot-splitting saw at work. As the ingots measure 18 inches by 20 inches or more in cross-section, this machine is very large and powerful.

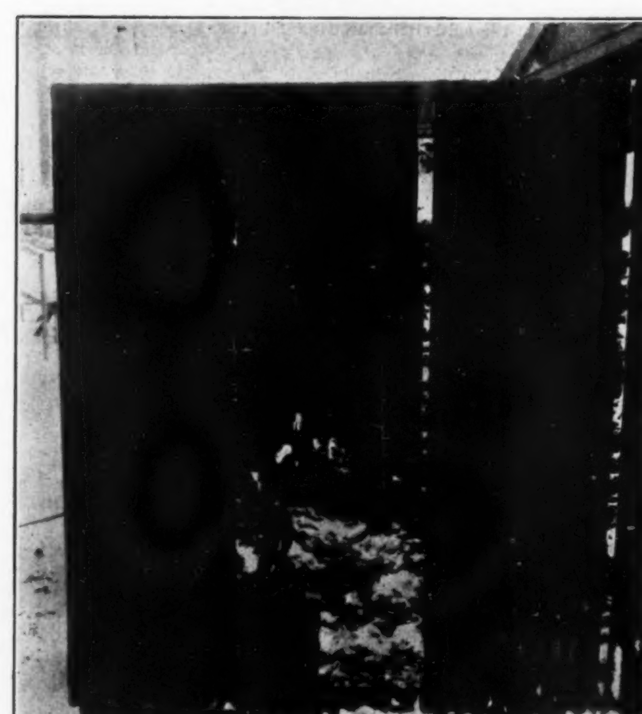


Fig. 17.—Illustration taken after eleven months' exposure in the box test, showing the failure of one type of sheet metal in competition with others.

In the review of the special constituents of steel, it was pointed out that certain extraordinary changes in the character of ordinary carbon steels take place, due to heat treatment through and about certain well defined critical points. The carbon-iron diagram shows that the hard constituents of steel are austenite and martensite, but if steels in which these constituents have been fixed by quenching and tempering are then annealed by high or prolonged heating, these constituents break down into the softer pearlite. Becker accounts for the influence of these rare elements as follows:[5]

"Tungsten acts first as a strong obstruction to all the steps in the change from austenite to pearlite, so that if we have 7 per cent or more of tungsten present, a moderately rapid cooling, even such as allowing the bar to cool in the air, will prevent the change to pearlite. Indeed, when tungsten steels are to be annealed and the pearlite stage produced, it is necessary that the cooling shall be very slow indeed, occupying several times as long as the annealing of normal carbon steels.

[5] O. M. Becker, *loc. cit.*, p. 40.

Fig. 7.—A group of llamas ready to transport the vanadium ore from the mines to the railroad.

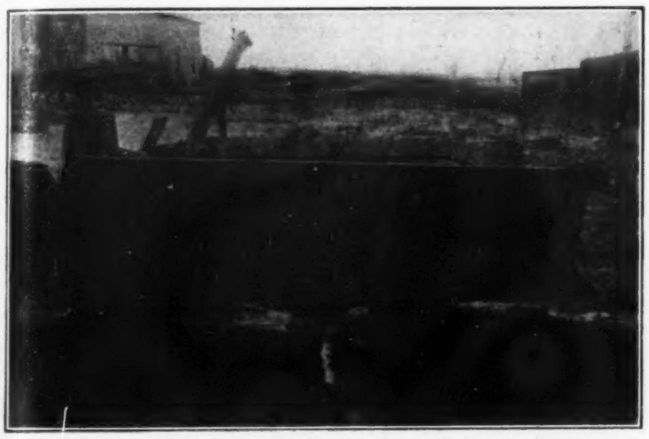


Fig. 12.—A longitudinal section of a piped ingot, showing great density and freedom from blowholes in the body of the metal.

Fig. 15.—A view of the proving ground where full-sized commercial steel and iron sheets are tested by the author for corrosion resistance properties.

Fig. 10.—Cross-section, showing an open or spongy condition of a commercial steel ingot.

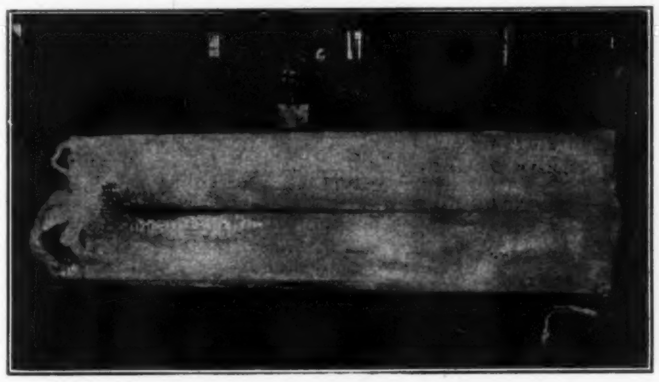


Fig. 13.—A longitudinal section of an experimental ingot, showing an extreme and dangerous form of piping.

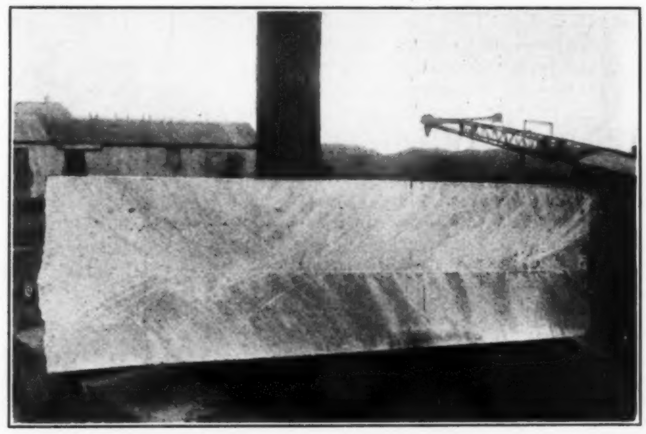


Fig. 11.—Longitudinal section of an ingot, showing improvement brought about as the result of careful research work.

Fig. 9.—Longitudinal section, showing an open or spongy condition of a commercial steel ingot.

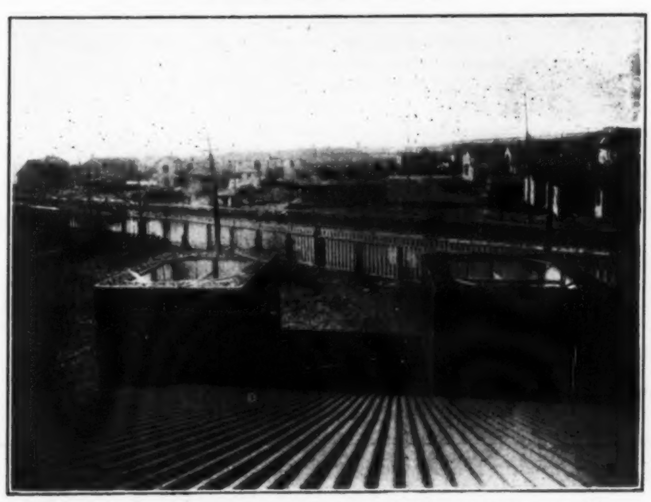


Fig. 16.—A new form of corrosion test. Hollow wall boxes built up out of test sheets and then filled with cinders or manure to accelerate corrosion.

"Tungsten acts, secondly, as a powerful fixing agent for martensite. It has been already shown that martensite is not stable in normal carbon steel even after it has been induced there by hardening, unless the metal be kept cool. Warming it up to the so-called temper heats changes the martensite over to troostite, and if the heating be continued, even the effective hardness of troostite is lost long before the steel reaches a red heat. The presence of 7 per cent or more of tungsten, however, increases the stability of martensite so much that the steel may be heated well above the tempering heats before the martensite even begins to break down into troostite or pearlite.

"Red hardness is the quality of hardness when at a red heat, and tungsten imparts this to steel under certain conditions, for a time at least. That is to say, we may cut with a tungsten steel at so rapid a rate that the point of a tool will reach that temperature where it almost begins to glow in a dark room, and still the steel will retain its hardness for many hours."

Vanadium, and vanadium and chromium together, are used to produce the wonderfully tough, anti-fatigue steels which are gradually supplanting all types of ordinary carbon steels in cases where very strenuous service is to be encountered, such, for instance, as in automobile and locomotive parts, and for springs of all sorts, which are more or less continually in motion. The extraordinary thing about vanadium is that less than two tenths of 1 per cent of this element is all that is usually necessary to confer upon steel this wonderful new property of resistance to fatigue. It is fortunate that this is so, for the principal source of vanadium is a vanadium sulphide ore which is painfully grubbed out of the sides and peaks of the Peruvian Andes, about sixteen thousand feet above the level of the sea. Fig. 5 shows the vanadium mines at Minas Ragra near the backbone of the Andes. Fig. 6 shows the Meigs Railroad leading part way up, constructed by Col. Meigs, the well-known American engineer. The ore is carried in bags on the backs of llamas to the sea coast, and eventually landed in the Pittsburgh district, where it is made into ferro-vanadium, an alloy of iron and vanadium, which, in turn, is used by the alloy steel makers in the manufacture of their special compositions. It is a curious thought that this rare material is found only in these apparently inaccessible places and then is carried upon the backs of llamas (Fig. 7), representing the most primitive form of transportation used in commerce, to find its special service in the manufacture of the most finished and developed means of transportation, such as the modern locomotive, automobile, and aeroplane. Fig. 8 shows a vanadium steel saw which was kept coiled for four years and when unstrapped came out almost straight.

Titanium finds its special use as a deoxidizer or purifier of molten steel, and it has been claimed that its use in small quantities produces great improvement in steel rails. The use of any element which claims to safeguard life by reducing accidents due to rail breakage must be watched with interest. Cobalt is the latest recruit to be enlisted in the making of high-speed steels possessing especially valuable characteristics. As cobalt is a by-product of the Canadian silver mines, an abundant supply for this purpose is assured.

Our time does not permit us to dwell longer upon the wonderful achievements of research as applied to metallurgy in the field of these special alloy steels. It has been the special province of the writer to investigate that region of iron metallurgy which lies at the other extreme. Thus far we have been mainly discussing the influence upon iron of carbon alone or together with the rarer alloying metals. In the manufacture of ordinary steels, a certain group of elements is always present as impurities. Some of these impurities are desirable, while some are present only because it has until very recently been found practically impossible to eliminate them on the large scale of operation made necessary by modern economic conditions. During the period of metallurgy which is comprised within the last century, men have been alive to the effects produced in iron and steel by the following elements which have often been referred to as the "big five." These are carbon, manganese, sulphur, phosphorus, and silicon. Owing to a peculiar condition of affairs that has arisen in the iron industry in America, we have now to add another common element of impurity, namely, copper, which changes the "big five" which the ordinary iron analyst is called upon to determine, to the "big six."

In 1905 the writer, who was then engaged in the conduct of certain research work in the United States Department of Agriculture, was called upon to make an investigation of the alleged extremely rapid corrosion of steel fence wire and other forms of steel used in agriculture. After a careful study of all the available sources of information, and an extended research inquiry in the laboratory, evidence seemed to be pointing strongly in the direction that a great improvement in many forms of steel would be produced if the five ordinary impurities then considered could be reduced or possibly completely eliminated. As the result of the publication of these researches and those of other workers in the same field, the electrolytic theory of corrosion was developed and is now commonly accepted as the explanation of the underlying governing principles upon which the rusting of iron and steel depends. In spite of its wonderful and useful qualities, ordinary impure iron and its derivative steel have the weakness of being easily attacked, not only by the moisture and oxygen of the air, but by all forms of acid action. The sources and ores of iron are all found in the highly oxidized condition, and iron is only won from this combination by the expenditure of enormous quantities of energy. Once divorced from its combination with oxygen, it shows a tendency to again unite with this element and thus return to its stable condition. One of the interesting and important fields for research, therefore, has been the study of this tendency toward oxidation and to devise ways and means of overcoming and, to as great an extent as possible, circumventing it. The electrolytic explanation of corrosion teaches us that the presence of the ordinary impurities in iron tends to stimulate the action and to throw the corrosive attack particularly upon certain points or nodes of an exposed surface, thereby producing that most dangerous form of corrosion, which is known as pitting or tuberculation.

It has already been shown that when a solution of salt in water is cooled toward the freezing point, it does not congeal into a homogeneous mass of salty ice, but a certain selective action takes place, resulting in a separation of the resulting crystals, ice, and salt. The same tendency exists when impure masses of mother metal cool down to the solidifying point. Some constituents crystallize out before others and become segregated. Segregation is one of the important problems that the modern research metallurgist is called upon to study, for it presents dangers from many different points of view if it is allowed to take place in an uncontrolled manner. If an ingot is segregated, the finished product of the ingot will be segregated and is liable to breakage or to corrosion damage, according to the nature of the product or the kind of service it is designed to endure. If segregation takes place as the metal cools and solidifies, the gases which are entrained or dissolved in the liquid bath cannot escape freely and therefore become entrained, producing an open or spongy ingot. Spongy ingots may be easier and less costly to bloom down than those which are solid and homogeneous, but there are, as the writer can testify, a number of honest and progressive manufacturers who are working to improve their ingots at the expense of very high cost in the maintenance of efficiently equipped research departments. It stands to reason that one way of overcoming segregation is to eliminate all alloying impurities, thus producing a pure iron in which there is nothing dissolved which can possibly segregate. The solution of the problem of producing such a pure iron on the large scale of operation demanded under the conditions of modern social economics and modern industry has been no easy matter. It involved from the beginning the doing of what contemporary metallurgists and metallurgical text-books stated it was impossible, or, even if possible, at best unwise to do.

The successful achievement of the results which are now obtained in the manufacture of pure iron on the large scale of open-hearth operation was not accomplished except as the result of very costly and strenuous research work in which determined men in the office, the mill, and the research laboratory joined forces with a common purpose and with loyal energy. The writer is proud of the share he has in this work and of the associations he has enjoyed with the group of men who have made it possible.

Where great strength is demanded, of course, pure iron is not suitable, but has many interesting properties which differentiate it from ordinary steels or alloy steels. Pure iron is very soft and malleable, and is capable of being most easily welded with the oxy-acetylene or oxy-hydrogen flame. A strip of this pure iron can be used as solder to join two ends or laps of the same material. It can easily be drawn into wire. Its electrical conductivity is 60 per cent better than ordinary soft or mild steel. The comparative resistance of copper being taken as one, that of commercially pure, so-called ingot iron is 5.3, of charcoal iron 5.4, of Norway iron 5.8, of soft steel 8. For this reason, this pure iron can be and should be substituted for steel in the manufacture of third rails in the electrification of railways. Every saving in the electrical resistance of the conductor is figurable into coal at the boiler end of the system.

In fact, this pure iron finds many interesting new fields of application, but its principal value so far has been due to its well known and well proven slow and even rusting quality. The writer has had comparative large scale exposure tests of various sorts and kinds under his observation for a number of years, and the pure iron seldom fails to give a good account of itself.

It has recently been claimed that ordinary steel alloyed with a little copper, say about 0.20 per cent, yields a metal of superior rust-resistance properties, and is therefore as good, if not better, than the purest iron. D. A. Lyon, speaking recently before this Institute,[4] voices this opinion in the following words:

" . . . the writer believes that there is more evidence to warrant the belief that the presence of copper in proper amounts in steel does prevent corrosion, rather than that it does not, or, as some claim, by reason of its being an impurity, promotes it."

I am one of those who do not agree with this opinion. It must be plain to everyone that even if in some respects, notably in conferring an added resistance to an acid test, the presence of a small quantity of copper is held to improve the steel, its admission as a basis of specification introduces a grave danger. Copper need not be, and generally is not, purchased by the manufacturer for introduction into steel, as it is much simpler to employ a cheaper grade of scrap as a material of manufacture, which contains the copper in the form of machine wastes. It seems inevitable that behind the screen of coppered steel specification will lurk the cheap segregated metals that modern research is trying so hard to work away from. Homogeneity and lack of segregation are the goal on which every progressive metallurgist has his eyes fixed, whether his special product is iron or steel.

Several recent lectures before this institute have discussed the bearing and importance of the production of sound ingots on the iron and steel problems of the day. You have heard of piped ingots on the one hand, and of spongy, blow-holed ingots on the other. Between these two awkward extremes the conscientious steelmaker is struggling as between Scylla and Charybdis. To a limited extent, the metallurgist has the making of sound ingots under control, but much remains yet to be learned in this respect. Five or six different methods or experiments for meeting this difficulty have recently been brought forward, but there is no record that any one of them has as yet proved its universal applicability. The difficulties attending this line of research are very great, as may readily be recognized. Modern ingots in big practice usually weigh at least 5,000 pounds and are 18 inches by 20 inches or more in cross-section and 5 or 6 feet long. If we vary our metallurgical practice, how are we to tell whether we have made any improvement? The only sure way is to saw a number of selected ingot in two longitudinally, and thus open to inspection and study the center of the mass. Such operation is difficult, slow, and costly. Yet it can be done, and the writer is fortunate in having under his supervision an ingot-splitting saw so powerful that it will cut in two one of these huge masses in a few hours (Fig. 14). Directed by such instruments of research as this, progress is rapid, and great improvement in quality, both as to strength and rust resistance of product, is constantly being made.

The possession of this ingot-splitting saw has made it possible to study corrosion problems with special reference to the interior condition of the original ingot. After an ingot is split and has been studied, it is possible to roll down sheet metal into the full commercial sizes from the ingot and then put the sheets out under atmospheric and certain accelerated tests. By this means it is possible to follow up the problem in a more intelligent manner than probably has ever been done before. In the illustration in Fig. 15 a general view of the atmospheric corrosion proving grounds under the supervision of the author is shown, and it includes many hundreds of full-size sheets of many types, manufactured from iron and steel ingots.

An interesting test which has been devised, which although an accelerated test shows some very extraordinary results, is illustrated in Figs. 16 and 17. Large hollow-walled boxes are made of corrugated test sheets nailed side by side as panels, and the hollow walls are then filled with either cinders or manure. By this means it is possible to get results on resistance to corrosion, of experimental materials, in from six weeks to six months, whereas in ordinary atmospheric tests generally several years are necessary before decisive results can be obtained, upon which any definite conclusions can be built.

In spite of the extraordinary vigorous competition and difference of opinion in respect to the manufacture of corrosion resistant sheet metal, it is the desire of the writer to come at the truth of the matter through the methods of scientific research. A few years more of this sort of investigation work should furnish dependable data upon which to base conclusions. In the meantime, the various announcements made by special interests, in regard to corrosion resistance problems, should be accepted only in the spirit in which they are made—that of a desire to obtain the largest possible market for their own particular type of product.

[4] *Journal of the Franklin Institute*, vol. clxxvii, No. 2, 192.

Probably no field of metallurgical research is more interesting or more important than the development of special steels for use in the manufacture of high-power electrical machinery. We are facing, if we have not entered, the age in which electricity will be the great universal servant of man's evolution. The research metallurgist has been quick to respond to the call of the electrical engineer and designer for special types of iron and steel to increase the efficiency and lower the costs of dynamos and transformers. Time will not permit me on this occasion to discuss the contribution of metallurgy to this most important line of progress. There is material enough connected with the subject to call for a separate and special paper. It is interesting to note in passing, however, that it has been estimated, by a well-known electrical research engineer, that the metallurgical improvements in transformer steels, brought about within the last few years by modern metallurgical research, represents a saving in money which would amount, if capitalized at 6 per cent, to approximately $15,000,000 in the experience of one great manufacturing company alone. The writer knows that this claim is not exaggerated, and such statements stand for themselves when they are vouched for by those who are familiar with the data involved in making such calculations. No better argument than this could be advanced to justify the claim that modern scientific investigators are continually making, namely, that properly guided research work pays; that it is not a mere refinement or trimming on the edge of industry, but, on the contrary, is a business asset which should be set down at or near the top of the column when the cost of high grade production is being computed.

One more thought and I am done. Research work is not alone the servant of the producer. Its results ramify in every direction. It does not seek to cheapen the materials with which the human race is carving its destiny, by degrading them in quality, but it does cheapen them by seeking to improve the methods of their production with due regard to the end and object they are designed to serve. Scientific research work in a nation is a national asset which should be understood and encouraged by all the people. In this country we are only just beginning to realize the importance of development along this line. Something has been accomplished, but, in closing this paper, the deathbed words of a great man recur to my memory: "So little done! So much to do!"

Testing for Open Circuit*

Simple Directions for Locating Troubles in a Motor

By F. A. Annett

An open circuit in the field coils of a motor may produce several different effects, depending upon the condition under which it occurs and the type of motor. If series wound, the motor cannot start, for the field winding is in series with the armature, as will be seen by referring to Fig. 1, where the field coil *C* is open at *X* and no current can flow through the motor.

In the shunt motor the field and armature windings form two independent circuits; therefore an open-circuit in the field coils will not interrupt the current flowing in the armature; see Fig. 2. In this type of machine a break in the field circuit may produce any of the following effects: The motor, if not loaded, will start if the brushes are not set at the neutral point. The direction of rotation will depend upon the setting of the brushes, but the motor will race and spark, and if an attempt is made to cut out all the starting resistance, the fuses will blow, or the circuit-breaker will open and there is likely to be burning at the commutator and brushes. If the machine is loaded, it will not start, and if the starting resistance is cut out, the fuses will be blown. With the brushes set on neutral, the machine will not start, but if they are given a backward lead, the armature will turn in the opposite direction.

A simple method of testing for an open field where a shunt or compound motor has been operating properly and suddenly develops trouble is: First, disconnect the armature connection on the starting box, as shown in Fig. 3, and move the starting handle upon the first contact. If the field circuit is complete when the arm is allowed to drop to the off position or the switch is opened, a severe spark will occur at the contact; if the field circuit is open, there will be no spark. The break in the field circuit may occur anywhere from the first contact on the starting box around to the line connection on the motor. After determining that the field circuit is open, it is necessary to find out whether the break is in the motor, the external wiring, or the starting box.

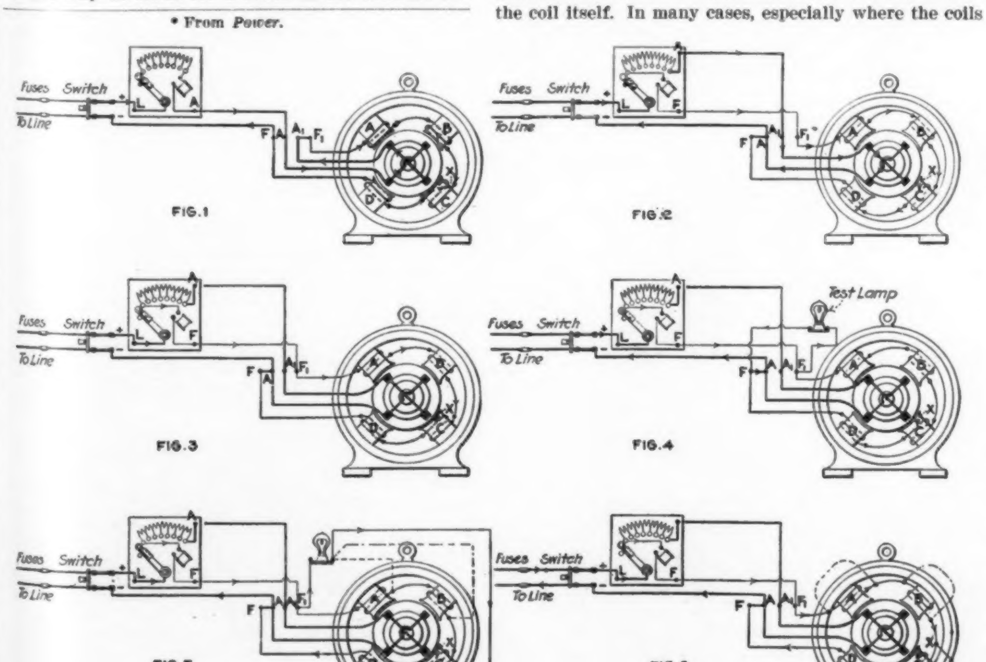
A test may be made for a break in the external circuit by opening the armature connection at the starting box, placing the arm on the first contact, as before, and connecting a lamp across the field connection on the motor, as in Fig. 4. If the lamp lights, the field circuit outside the motor is complete, as indicated by the arrow-heads.

After it has been found that the break is in the field winding, inspect the connections between the field coils to see that none is broken or loose. After these are found to be in good condition, the defective field coil may be located as shown in Fig. 5. Place the starting-box arm on the first contact and connect one terminal of the test lamp to one of the field terminals of the motor; in this case F_1. With the other lamp terminal make connection between coils *A* and *B*, as indicated by the dotted line. In this position the lamp will not light, for the circuit is open at *X* in coil *C*. Next connect the free lead of the lamp between coils *B* and *C*, also indicated by the dotted line; again, it will not light. However, when connection is made between coils *C* and *D*, as shown by the solid line, the lamp will light, for now the open coil has been bridged. Since the lamp will not light between coils *B* and *C* but will light between coils *C* and *D*, it shows that coil *C* is open-circuited. Where a test lamp is not at hand, a piece of wire may be used to bridge one coil at a time, as shown in Fig. 6. First, short-circuit one coil as indicated by the dotted line at *A*, then close and open the switch. If a spark occurs when the switch is opened, the open coil has been bridged. In this case, however, it does not occur until coil *C* has been short-circuited, as shown by the full line. After the open coil has been located it should be disconnected and again tested through with a lamp to be absolutely sure that it is defective.

The open circuit often occurs where the leads are connected to the coil winding; this may be easily located and repaired. After the coil has been opened up it should be tested back of the splices where the coil connects to the leads to make sure that the trouble is in the coil itself. In many cases, especially where the coils are not wound on a spool, the open-circuit can be located and repaired without rewinding the coil, for if not found at the points mentioned, it usually can be located in the coil itself by a burned spot on the insulation caused by arcing when the coil opened.

An open-circuit in the shunt field of a compound motor will have practically the same effect as in the shunt motor, except that the motor will usually start whether loaded or not, as the series field will provide sufficient torque to start under full load, but the machine will usually race in either case. The break in the shunt field may be located in the same manner as described for the shunt machine. An open-circuit in the series field will cause the machine to fail to start in the same way as described for the series motor in Fig. 1.

* From *Power*.



How to test for open circuit in field coils.

Radioactivity of Mineral Waters

The radioactivity of mineral waters has attracted much attention during the last decade, and it is now widely believed that the therapeutic value of many waters is largely due to their content of radio-active substances. For many years the beneficial effects attending the use of certain natural waters were attributed to the common mineral ingredients determined by chemical analysis, and several elaborate systems have been devised for classifying such waters on the basis of their chemical composition. Though many natural waters unquestionably cause physiologic reactions because of their great content of common mineral substances, a large proportion of the well-known waters of the United States do not differ essentially in concentration and composition from supplies of city water used daily by thousands of people without apparent physiologic reaction other than that following the use of water itself. Tests have shown that many of these slightly mineralized waters have various degrees of radioactivity, and consequently, as radium compounds have been found to cause marked physiologic reactions, the improvement in health following sojourn at springs has very naturally been attributed to the radioactive properties of the waters. There are yet too few experimental data to settle this point definitely, but it is perhaps not out of place to call attention to the facts that in radiotherapy as in all other branches of medicine the curative agent must be present in a certain strength in order to exert any healing influence, and that most of the radiotherapeutic reactions thus far investigated have been effected by means of radioactive compounds whose strength is far greater than that of natural mineral waters. Therefore owners should not be led into making strong claims for the radiotherapeutic value of the waters of their springs without careful investigation of the subject.—R. B. Dole in *Mineral Resources of the United States*, 1913. Part II: 24.

Quick Track Repair Methods

When a trolley track is to be repaired in a city, or any other considerable work is to be done, a great deal of time is lost, and the street is obstructed for a longer time than necessary, by the slow present process of pulling up and removing the pavement between the tracks. An up-to-date method of procedure has been adopted in Cleveland that greatly facilitates the work and saves considerable time as well. A special heavy cast steel plow, of suitable shape, which, with its car and weighting weighs eleven tons, is hauled by a powerful service car and rapidly breaks up and lifts any granite pavement, and at the same time cuts the track tie rods. With this equipment a crew of three men can break up 1,300 square feet of pavement a minute.

The Electrically-Driven Gyroscope in Marine Work—II*

The Toy of Yesterday Now a Valuable Scientific Instrument

By H. C. Ford

Concluded from Scientific American Supplement No. 2025, Page 269, October 24, 1914

A most important use of the gyro compass is on submarine boats which derive their power, when submerged, from storage batteries, the voltage of which varies at times from as high as 160 volts down to 100 volts at the end of a long run. An economical form of voltage regulator has been devised for such service.

The problem of accelerating and driving the heavy balance wheel (the compass wheel weighs about 45 pounds or 20.4 kilogrammes) at a velocity of about 8,600 revolutions per minute required the design of a special form of generator, three-phase current at 90 volts being used. The characteristics of the generator allow of the wheel being thrown directly upon the line and brought up to full speed automatically in about thirty minutes without attention on the part of the operator and without the use of excessive current. This machine, shown in the background of Fig. 10, has a capacity of three amperes per phase, but is ordinarily run under a load of 0.9 ampere.

The 20-volt direct-current dynamotor also shown in Fig. 10 is used in supplying energy to the servo motor follow-up system and for operating the secondary or repeater compass system. No special features of design were necessary other than to meet the usual requirements on shipboard as to commutation, rating, accessibility, etc. In battleship equipments, both of the above generating units are ordinarily supplied in duplicate.

An emergency direct-current service is provided by the employment of a 20-volt storage battery which is kept floating upon the line at all times. This provides energy for operating the follow-up system of the compass whenever the ship's service has failed. During such times the gyro wheel, on account of its great inertia and ease of operation in vacuum, will remain spinning and will give ample directive power for an hour or more after the power has been shut off, so that the compass is rendered fully effective under all such conditions. This constitutes a unique and extremely valuable feature of the Sperry compass.

An independent six-volt battery and alarm bell are employed to notify the attendant promptly of any interruption of current or failure in operation of various parts of the system which would be likely to cause errors in the compass readings, so that the same may be corrected without delay. A trip relay is provided which keeps the bell ringing until the attendant has corrected the difficulty and reset the trip.

A reverse current relay is provided for disconnecting the direct-current dynamotor from the storage battery and line upon failure, or any material reduction in voltage of the generator or ship's supply line, and for connecting the generator in again when voltage has been restored to normal. This, of course, prevents the rapid discharge of the storage battery in driving the generator.

Especially designed switches and controlling apparatus are provided, which include a small and compact switch for throwing both the voltmeter and ammeter at once upon any one of a number of different circuits or phases. These switches are of the rotary or controller type and are inclosed in gas-tight cases to prevent danger of explosions when used in submarines.

The gyro motor is of the three-phase induction type, the squirrel-cage secondary forming a rigid part of the inner rim of the revolving wheel shown in Fig. 11.

On account of the high speed of the rotation, wheels have to be given a very careful running balance, which is accomplished by the use of various size studs threaded into holes at the periphery of the wheel on each side.

The stator also shown in Fig. 11 is mounted on one side of the main vacuum casing containing the wheel. A spiral line is painted on the wheel which, when observed through a window in the casing by means of a stroboscope, enables one quickly to determine the speed of rotation.

The servo motor or follow-up system forms an important part of the gyro compass and performs three functions, of which the first is to shield the gyro from all external forces and friction. This is accomplished by the method of carrying the supporting filament, and all guiding bearings having to do with the sensitive element, within an outer frame known as the phantom (Fig. 12), which completely shields the element from all disturbing external forces.

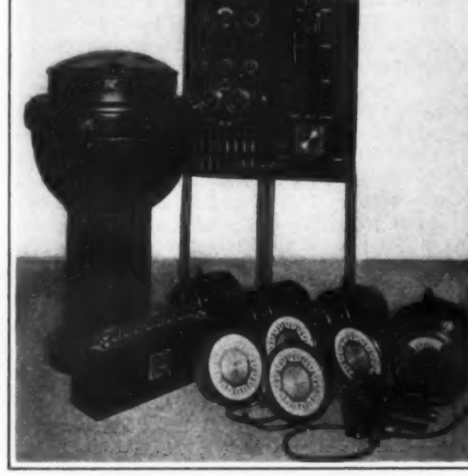


Fig. 10.—Complete equipment for a gyro compass installation on a battleship.

Fig. 11.—Rotor and stator of the gyro motor.

The suspended mass of the sensitive element, which including the wheel casing and the vertical supporting ring, weighs about seventy-five pounds, is by the above means rendered actively sensitive to a force couple of 1/4,500 inch-pound, which represents a force of less than one-four-millionth part of its own weight acting at a radius of one foot. This degree of sensitiveness is actually measurable in the operation of the compass which is thought to be somewhat remarkable in this respect.

A second function of the servo motor, which in the gyro compass is known as the "azimuth motor," is to operate the transmitter for sending out indications to any number of repeater compasses located at distant parts of the ship. The main azimuth scale of the compass is also carried on the power-driven member.

The third function of the azimuth motor is to operate the correction device before mentioned, which by means of cams solves a trigonometric equation involving the factors of speed, latitude and heading of the ship, and automatically introduces the proper correction into the compass readings, which are therefore maintained accurately upon the meridian. Fig. 13 shows the front of the correction device and dials which are set at the proper speed and latitude.

The azimuth motor with its reduction gearing is shown in Fig. 14, and is provided with ball bearings throughout. An inertia brake consisting of a balance wheel mounted and driven by friction on the armature shaft serves to damp the oscillations or hunting of the azimuth motor, while offering no resistance to continuous motion.

The secondary transmission system comprises a contact making transmitter and six-pole step-by-step motor connected by three circuits having a common return wire. The transmitter (Fig. 15) is provided with three pairs of tungsten make-and-break contacts which are operated by cams. The construction of the repeater system is such that the motor may be driven at speeds as high as 1,000 revolutions per minute, or 100 cycles per second, without getting out of step.

The repeater motor is geared to give six steps for each indicated degree in azimuth and the repeater compass instantly follows all changes of the master compass for every movement of the ship. The repeaters are provided with compass cards made of translucent material to permit of illumination from within.

A manually operated transmitter, or synchronizer, is used for setting the distant repeaters into agreement with the master compass in connection with a magnetic stop for each motor, by means of which the repeaters are first collected upon a common reading and then brought at once to read with the master which is then thrown into circuit.

The exceptionally fine results obtained with the gyro compass here described have fully justified the long and painstaking efforts that have been expended in its design and in the practical solution of the many problems met at various stages of its development and in actual use at sea.

When subjected to the most drastic tests, far greater in severity than any actual conditions found on shipboard, the compass continues to hold to the meridian within a fraction of a degree. In fact, every compass before being accepted by our government has to pass through a series of such tests lasting several weeks, during which time the maximum error must not exceed ½ degree in azimuth when swung continuously for six

*Paper read before the American Institute of Electrical Engineers and published in the *Proceedings* of the Institute, vol. 33, No. 6, p. 873. Copyright, 1914, by American Institute of Electrical Engineers.

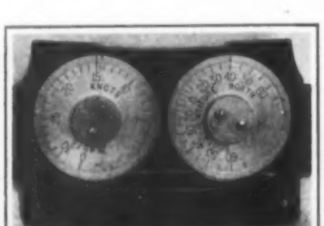


Fig. 13.—Automatic correction dials. Setting 15 knots, 40 degrees north latitude.

Fig. 12.—Power-driven frame or "phantom" arranged to shield the directive element from external disturbances.

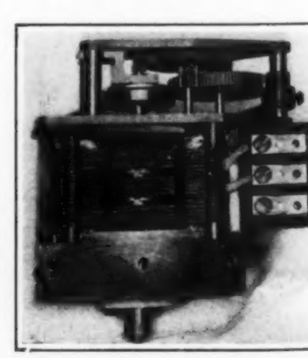


Fig. 14.—Azimuth motor for driving the phantom.

ys at a time under conditions of rolling, pitching, and wing of an artificial ship.

It should, of course, be understood that under similar nditions on board a battleship or submarine the magetic compass would be almost, if not entirely, useless. Even under the best of conditions, navigation of a steel hip by magnetic compass entails a large amount of

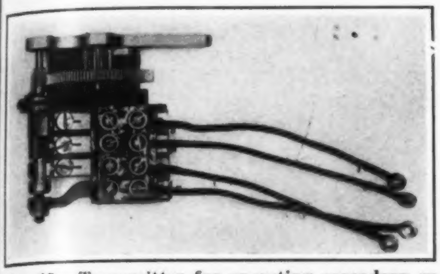


Fig. 15.—Transmitter for operating secondary or repeater compasses.

xtra work with considerable liability of error in aplying variation and deviation corrections of various mounts, plus or minus. With the gyro compass decribed, all readings are made exactly upon the meridian and the navigator is always sailing on true courses. The quick and accurate indications of the compass for the slightest deviation or yawing of the ship have enabled much straighter courses to be steered, with a resulting saving in fuel and increased speed. For intricate maneuvering in battle practice, the ship may be controlled perfectly from various protected steering stations, and the master compass is completely shielded from the fire of the enemy and from the shock of gun fire.

In submarines the gyro compass enables an accurate course to be laid when running submerged, so that after obtaining the bearing of the target from a great distance the submarine may approach, submerged, to within a short distance and fire its torpedoes accurately.

From an instrument having a degree of sensitiveness to force couples measured by one-four-millionth part of its own weight it is rather a long jump to consider another type of gyro possessed of many tons of stored energy which may be harnessed and made to work not only to hold a mammoth ship against rolling in high seas, but actually to roll the ship for the purpose of sliding off a sand bar or breaking through an ice flow.

Gyros of this type have already been built, tested, and thoroughly investigated, and a gyro of thirty tons weight, capable of exerting a force couple of over four million pound-feet, is now under construction for stabilizing the steamship "Ashtabula," used as a car ferry on Lake Erie.

In two papers read before the Institute of Naval Architects and Marine Engineers in November, 1912, and December, 1913, Mr. Sperry has treated very ably and comprehensively the subject of stabilizing ships, and has made some striking comparisons which show his valuable contribution to the art in the "active" type of gyro. In the last paper referred to are shown characteristic rolling and damping curves for ships equipped with active gyros when subjected to various wave impulses and frequencies. These curves, some of which are here reproduced in Fig. 16, were obtained from a model ship pendulum, the dimensions of which were adjusted to correspond to a 19,000-ton ship at the linear ratio of 1. 30.

The stabilization is practically complete, as indicated by the curves in Fig. 16. Early in this work observations were made indicating that the stabilization was complete even when the wave increments received from the sea were greater than the theoretical power of the gyros mounted in the ship.

The work with the stabilizer has shown that it is perfectly easy to stabilize against all wave increments received by the ship from the sea which are equal or less than the stabilizing capacity of the gyro equipment. Stabilization is so complete under these conditions that interest in this part of the performance has been transferred to investigations of the region where the wave increments are actually in excess of the stabilizing capacity.

The curves in Fig. 16 are among the results obtained in this connection, and it will be seen by carefully scrutinizing the cards that none of the curves are taken where the wave increments are not larger than the roll-quenching increment, and even under these conditions the stabilizing is practically complete for practically all the wave periods.

Practical data of great value were obtained from the construction of an active gyro plant which was tested out repeatedly on the U. S. S. "Worden" during the summer of 1912. This plant was the largest gyro installation ever built and consisted of two gyros weighing about three tons each which were operated actively by use of a precession engine.

Fig. 17.—One of the two large gyros of the U.S.S. "Worden" while under preliminary tests at the Navy Yard, New York.

The gyros were automatically controlled so that they responded instantly to all wave increments encountered, whether in harmony with the period of the ship or not.

Fig. 17 shows one of the "Worden's" gyros bolted on a heavy base plate while under test at the Brooklyn Navy Yard. The base was loaded with pig iron, which, with the load of the gyro and precession engine, brought the total weight up to over thirty tons. The gyro very effectively demonstrated its power by actually lifting this heavy load, tilting the whole base plate up on edge and rocking it back and forth as the gyro was processed.

Fig. 18 shows the precession engine.

The results prove conclusively that the active type of gyroscope as applied to the control of a ship's rolling motion is of vastly greater efficiency and economy than any other form of stabilizer yet proposed. The efficiency is demonstrated by the action of carefully calculated scale models and is completely verified by the long-continued performance at sea of the gyro plant on the "Worden." The economy is evident from a comparison of the space and weight required in an installation of the active gyro relative to that required by the most effective form of water damping tanks or other stabilizing means.

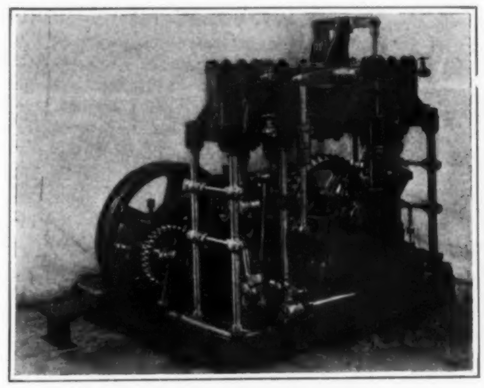


Fig. 18.—The precession engine.

Careful calculations show that an active gyro plant for stabilizing the steamship "Ashtabula" will require less than one tenth the space and weight which would be necessary for equivalent stabilizing with the best designed water pendulum.

The results further show that it is now possible to completely stabilize any ship against rolling by means of an active gyroscope, requiring a very small percentage of the weight and space available in the ship. This work has opened up a wide field of usefulness in the application of the gyroscope, and its application to passenger vessels will be watched with interest.

Photo-Electric and Photo-Chemical Action

The experimental complexity of the relations between the number of emitted electrons and stimulating radiation makes advisable a wide basis for a theory of these actions, and an attempt is made by O. W. Richardson, in a paper read before the American Physical Society at Chicago, to develop such a theory on the basis of the energy abstracted from radiation in liberation of an electron or atom, and since the argument is unaffected by existence of change the term "atom" may be taken to include ions and electrons. The fundamental equation obtained involves the assumption, as yet not tested experimentally, that the number of atoms emitted by a given amount of light is the same whether light is or is not decomposed, without energy loss, into its spectral constituents, which is the simplest assumption consistent with photoelectric evidence that the number of emitted electrons is simply proportional to the intensity of light of definite spectral composition, but varies greatly for equal energies and for different frequencies. It is also assumed that: the distribution of energy in the radiation is given by Planck's formula; that photochemical actions are fundamentally independent of temperature at low temperatures, as is indicated by the experimental evidence, and that they do not contravene the second law of thermodynamics; that the contribution of the radiation to the mean internal energy of the emitted atoms, i. e., their kinetic energy in the condensed form, is negligible.

This last assumption is a very real restriction of the theory, which it makes essentially a provisional one, since the whole of the internal energy of the atoms might quite possibly arise from the radiation. The fundamental equation is then shown to lead to the conclusion that $\phi(\gamma) = h\gamma$, where h is Planck's constant, and $\phi(\gamma)$ is the mean energy which each atom, liberated under the influence of monochromatic radiation of frequency γ, has acquired from the radiation at the moment of liberation. It is then further shown that a consistent scheme of relations may be framed whereby this equation may hold good at all temperatures. In comparing the scheme so formulated with experiment, it must be remembered that the neglect of the part played by electron reflection in the electrical case, and by corresponding atomic deflections in other types of photochemical action, although not affecting the equilibrium values, will affect photoelectric results dealing, not with a state of equilibrium, but with the rate of emission under a given illumination.

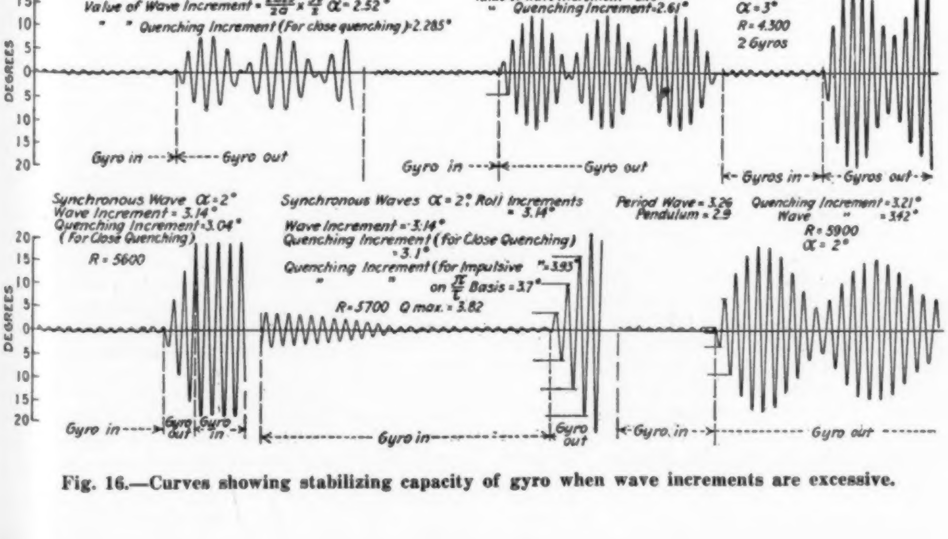


Fig. 16.—Curves showing stabilizing capacity of gyro when wave increments are excessive.

Nodon Electrical Process

For Rapid Drying and Preservation of Wood

French technical journals are interested in the process invented by Albert Nodon for the rapid drying of wood by means of electrical currents, which at the same time are a preservative agent and a destroyer of germs of whatever nature that may be within the wood. Nodon's first researches with reference to lumber date as far back as 1896, when he devised a process for "ageing" wood, but it involved complicated and costly technique and proved to be not always practicable. He has, during the intervening time, engaged in long and careful researches, and now* describes his method, of which he claims the action is regular and certain.

The action of electricity upon wood he notes to be triple in character: chemical, physical, and aseptic. The chemical action consists principally in the complete and rapid oxidation of resinous matters, the physical action results in molecular changes in the cellulose which modify its mechanical properties and tendency to decay, while the aseptic action consists of a complete and definite destruction of all parasites and agents within it acting for dissolution.

Wood is a living substance and is prey to destructive organisms, largely inherent, as soon as it is felled. Preserving processes are therefore of greatest interest and value. The problem is complex, and for that reason the methods usually employed are incomplete and insufficient. It is necessary to a process that shall be successful that it be simple and inexpensive, and that it be practicable not only in permanent mills, but even at the place of the lumber operations. It should be equally applicable to logs and to lumber, uniform in its action, and should not be of a character to interfere with drying in the open air. It is claimed by Nodon that wood dried by his process no longer shrinks and swells with the weather and that its strength is in no way impaired, but on the contrary is somewhat increased by the operation. Its limitation is set at peeled logs, especially if partly dried, for these no longer retain sufficient moisture to conduct the electric current.

Drying of Wood.—One of the most important industrial questions with lumber is its rapid drying. As the industries consume ever-increasing quantities of stock, and the number of trees is constantly diminishing, the result is that it can no longer be kept in the old-fashioned way till it is properly dried. The industries chafe at holding idle the capital necessary for such vast quantities of material, and kiln drying has therefore pretty generally replaced the natural method.

Unfortunately kiln drying has its defects. The desiccation is often only superficial and the wood afterward absorbs moisture with avidity when it has the opportunity. The presence of the sap opposes itself to kiln drying, and methods of getting around this difficulty by steam at high temperature and pressure are not very satisfactory. Such a process, moreover, is an injury to the lumber, and affects its life, strength, and durability. Under the heat and moisture the cellulose and its derivatives begin a change into dextrine and glucose. There is truly no comparison between the kiln dried and the naturally dried stock, and in addition the injury that haste causes is at the further cost of expensive heating plants and continually increasing price of fuel. All these factors have joined in raising the price of lumber.

Nodonization, on the contrary, secures in a very short time the oxidation of the sap which would be accomplished slowly in the air, and it changes various materials within the wood into resins. The oxidizable content of the sap has great hygroscopic qualities, and when dried in the kiln seizes moisture when it can, but transformed into resins it loses this appetite, or rather thirst. It is such oxidation that gives to the natural process of drying its evident advantages. But in thick logs or lumber the process is exceedingly slow. The electrical current is able to accomplish in a short time a work more complete and uniform than would years of open-air drying. Nodonization is a process in which electricity acts on the sap and puts the lumber into a condition where a short supplementary outdoor exposure will dry it thoroughly, while logs felled at the same time but not treated will yet be hardly dry on their surfaces. Even in trees that have been cut for some months the electricity will secure results if only there be retained sufficient moisture to insure conduction. Trees may be treated immediately after cutting and thereby be protected from any possible deterioration.

Preservation of Wood.—A part of the process that is set forth by Nodon is that the current completely and rapidly oxidizes and turns into resins many of the materials in the wood such as albuminoids, gelatins, glucoses, and tannins. At the same time the current has a microbicidal effect on all living germs that the green wood incloses, which are ordinarily the cause of the rapid destruction when the wood is finally exposed to air and moisture. There are many agencies of ferment and destruction within the wood cells—starches, sugars, diastases, etc., besides proteids, albuminoids, and nitrates, which are easily changed. The process of decay is outlined by Nodon, who notes, in addition, that there are yeasts, mosses, and fungi that bear their part in the destruction of the wood. The tree has in it while living the causes of its future decay, and as soon as its vitality is weakened these begin to act, especially in the presence of heat and humidity.

Nodon's process, he claims, destroys all the germs and parasites, large like some of the fungi or microscopic in size like the bacteria, which are already in the lumber, while it so transforms the material of the wood as to make it resistant to decay-germs from the outside. Treated wood likewise resists the attack of insect destroyers which do not here find their suitable environment.

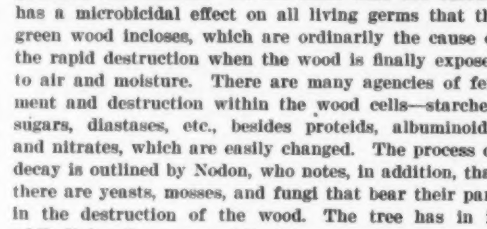


Fig. 1.—Pile of timber ready for the Nodon process. Cylinder at left, a mat-electrode rolled for carrying.

Practical Application of the Electrical Process.—The method of Nodon is illustrated in Figs. 1 and 2. Both diagrams show the method of piling wood in layers separated by mat-electrodes, which afford a means for the application of the current. Such mats, the section of which is shown in Fig. 2, are flexible and may be rolled into a cylinder about a stick after the fashion of ordinary house rugs. Fig. 1 shows to the left a mat-electrode thus rolled. The mats are made up of a flexible web of galvanized iron between two thick jute coverings. They are good conductors of electricity when wet and are spread between the layers of lumber.

Fig. 2.—Pile of lumber ready for treatment. Below, section of mat-electrode.

C, switch-box; *B*, *B'*, poles connected with alternate mat-electrodes, *E*; *T*, lumber; *m*, flexible metal web; *t*, *t*, jute cloths.

When the drying process is conducted in a factory or mill it is easy to arrange a platform on which to lay the first mat, then comes a layer of green wood, dimension stuff, planks, girders, joists, and the like. The pile is built up of alternate mats and layers of wood until it is from three to five feet in height, the mats being well moistened. Alternate mats are connected to opposite poles, and the process begins. The current will then traverse individually the layers of wood and the resistance will be the minimum. The electricity passes through the wood in the direction of its smallest dimension.

The conductivity of the lumber is very different, according to the kind of wood, its thickness, the degree of humidity, and the season when it was felled. The resistance may vary from 6 to 20 ohms per cubic meter (one cubic meter = 35 cubic feet), and to circulate a current of 5 to 6 amperes through a cubic meter of wood in the form of joists, an electromotive force of from 30 to 100 volts will be necessary. The resistance of a pile of lumber thus placed remains constant through a treatment.

An alternating current should be used by preference; 40 to 50 cycles at 110 to 120 volts is suitable, although it is better to use a lower frequency, 15 to 25 cycles, and a lower voltage. It is, of course, practicable to adjust the electromotive force by means of resistance. It is possible to use the direct current, but at a disadvantage, for it produces electrolysis that destroys the mats. Such a current of 110 volts is suitable, but it is necessary to reverse it by hand from time to time.

Treatment in the forest is effected with great advantage when the wood is in the sap in the summer, for then it presents its maximum of vitality for industrial purposes, and it is also the most favorable season for drying in the natural way. Piles of wood with their mats can be disposed at the place of felling, and the treatment may be continued day and night. When the treatment is finished the lumber may be piled in suitable places near by, and the drying completed naturally and in the space of a few weeks. Treatment in the woods is economical since power is cheap, and the great costs of transporting sap and waste are avoided. The time of treatment varies from one to two full days, according to the nature of the wood and the results desired. Wood, if treated too rapidly, develops cracks and flaws, although its strength is the same as with the slower process. The treatment varies also, according to the purpose of the wood, it being desirable to regulate the current to from 4 to 5 amperes for the arts like cabinet work, furniture or finish, while when it is for rougher uses like girders and joists, paving blocks, or railway ties, the current may readily attain 10 amperes.

The total current that a cubic meter of wood should receive should be about 150 ampere-hours. It makes little difference if the operation is suspended at night, it being simply necessary to keep the mats wet, so that the resistance of the wood will not increase. Wood in the sap does not require above 40 volts, but logs in the bark may need from 80 to 100 volts.

Costs.—The cost of a plant of this kind is merely that of the mats and of the electrical plant and running. The price of mats is low, about 80 cents (four francs) a square meter, and for mats enough to treat a cubic meter of wood a day about $8. The mats will last a year if properly cared for. The depreciation is therefore about two cents a day per cubic meter of wood.

Comparisons made by Nodon of costs in the factory and the forest are given, the latter being much the smaller since there is less to pay for fuel, for handling, and for transportation.

FOREST.	
Current, 3 kilowatts at 1.2 cents	$0.04
Handling and transportation	.40
Depreciation	.10
Total	.54

FACTORY.	
Current, 5 kilowatts at 3 cents	$0.15
Handling and transportation	.50
Depreciation	.12
Total	.77

With reference to industrial applications, Nodon gives some local facts. Wood so prepared is useful in the ordinary ways of building, finish, furniture, ships, railways, ties, paving, etc. In France there is much imitation mahogany. It arrives from Africa in a few days after cutting in great logs filled with sap, and the treatment of these in the kiln has not been very successful. Wood paving has been little used in the country on account of the high cost compared with durability. Bordeaux has approved the Nodonized pavements, and Paris is now testing them in some streets of important traffic. It is well, according to Nodon, to treat the paving blocks while warm in a bath of waterproof liquor like creosote or tar and to cover them with a protecting layer. This will keep the pores closed, for even with its advantages the Nodonized wood is not stone.

If processes for preserving woods are to be adopted, they must be forced on the producer by the consumer, as the timber owners prefer present high prices without regard to the requirements of the future.

* From *Le Génie Civil.*

Superheaters on Locomotives

It may be said that, with possibly the exception of the Glasgow and South-Western Railway, there is not a single important railway in the British Isles that is not now using superheaters for locomotive work, a truly remarkable instance of the rapid adoption by locomotive engineers of progressive ideas, seeing that only a few years ago the superheater was practically unknown on the railway.

British engineers, however, are not alone in thus speedily recognizing a good thing. Of that fact there was ample evidence at the recent Paris meeting of the Institution of Mechanical Engineers, particularly in the paper by Professor Edouard Sauvage on "Recent Development of Express Locomotives in France." According to the professor, with the exception of some Atlantic type locomotives—which are not likely to be reproduced, by the way—all engines built for express work in France during the past decade are six-coupled, being either ten-wheelers (4-6) or Pacifics (4-6-2). On these superheated steam is largely used, with a few exceptions, the Schmidt standard superheater being the type generally adopted.

With regard to this increasing use of superheaters, Professor Sauvage makes the interesting comment that owing to the large tubes necessary to receive the superheating pipes, it frequently happens when a superheater is fitted to a locomotive boiler that the proper heating or vaporizing surface is greatly curtailed; in fact, in many engines the total of the heating and superheating surface is less than the heating surface that night have been obtained without superheating.

Without superheaters the heating surface equals 72 to 77 times the grate area in engines having narrow fire-boxes, and 60 to 62 times in the case of wide fire-boxes. With superheaters the ratio of proper heating surface to grate area is as low as 50, and does not exceed 60. Although the results in service are good in all cases of superheating, this large reduction of heating service can hardly be regarded as entirely satisfactory.

No difficulty is reported to arise from the use of superheaters. They are found to be easily kept in order, and valves and pistons, when properly lubricated with an efficient oil, do not give signs of undue wear even with a high superheat—up to 340 deg. C.

Except in the case of one French company, all engines for express service have four cylinders, with a large proportion of compounds. In a few cases simple expansion, in four equal cylinders, is used, but the compound system appears altogether to be preferred. The one exception is the recent building of the Midi Railway for express purposes, of simple engines with only two cylinders and using superheated steam. Of course, simple engines on this principle exist on other railways, but they are not used for fast service.

When superheaters have been added to the four-cylinder compounds, the diameter of the high-pressure cylinders has been increased, the low-pressure cylinders being left unaltered. Piston valves are generally used on all cylinders, even on non-superheaters, but in a few cases, for instance, on Paris-Orleans engines, flat valves have been preserved on the low pressure cylinders of superheaters.

Other systems of superheaters besides the Schmidt have been experimented upon. At first, for fear of overheating the high-pressure cylinders, superheating in two stages was resorted to; high-pressure steam being moderately heated, receiver steam being passed to a second superheater. This plan, Professor Sauvage records, has been abandoned. A helical superheater, on the principle of the field tube, with ribs, was fitted to some engines, and was abandoned on account of its insufficient surface and of the difficulty of cleaning its outside ribs. Another system tried is known as the Mestre "squirrel-cage" superheater; this is working on some engines, and gives ample surface.

On the French railway—the Nord line—the engineers speak most favorably of their superheaters, and they agree that to get the best results superheating must be combined with compounding, a system which is to be adopted in future locomotives. It is found that with steam temperatures of 300 deg. to 340 deg. C., no undue expenses for repairs have had to be met. As regards actual working experience, we have the testimony of the chief engineer of the Nord Railway, M. Asselin, who advised Professor Sauvage that "until 1904 our fast engine was an Atlantic without superheater, a four-cylinder compound with a horse-power of 1,400 (1,380 b.h.p.). The first step was to increase the power of these Atlantics by the addition of a superheater. Although taking heavier trains, these engines with superheaters showed an economy of at least 5.3 lb. of coal per mile. The second step was to build Pacifics of about 1,900 h.p. (1,873 b.h.p.). It is remarkable how economical these engines proved. With the same weights they consume practically the same quantity of coal as the Atlantics with superheaters; and with the heavier loads than the latter could manage without superheaters the Pacifics burn less coal."

Other valuable comparative data were collected by the chief engineer of the Paris-Orleans railway, who made an interesting comparison in actual running of twenty Pacifics without and of fifteen with superheaters. The mean coal consumption per 100 ton-mile was in winter (including steam for heating the trains) 13.8 lb. for engines without superheaters, and 12.4 lb. in the case of engines with superheaters. A saving of no less than 10 per cent. is thus shown to exist in favor of the superheat. Thanks to superheating, it can be placed on record that in a period of fourteen years, during which the weight of trains on the Nord Railway has been doubled, the coal consumption has remained practically stationary, and it is much the same story on many other lines.

But, as has been pointed out by those eminent English locomotive engineers, Messrs. J. A. F. Aspinwall and G. Hughes, the coal bill is only one item of expense in locomotive working, although the rise in the price of coal makes it more and more important; the economy of first cost in the case of two-cylinder simple engines must be taken into account.—*The Daily Telegraph.*

Explosive Mixtures of Gases*

An explosion is essentially a very rapid combustion which occurs almost simultaneously in all parts of a mass of combustible substance. The heat developed by the combustion raises the gaseous products of combustion to a very high temperature, and gives them the enormous pressure and expansive tendency which produce the destructive effects of explosives.

In order that combustion shall be almost instantly propagated throughout a mass of gas it is necessary that the air required for combustion shall be intimately mixed with the combustible gas, and in order to attain the high temperature requisite for explosion the mixture must not contain a large quantity of gas that takes no part in the combustion, for such a mass of inert gas would exert a cooling effect. This consideration leads to the law, which is confirmed by experience, that mixtures of combustible gas with air are explosive only when the percentage of combustible gas in the mixture lies between certain limits. These limits, for some important gases and vapors, are given in the following table:

Gas or Vapor.	Percentage of Gas in Explosive Mixture. Upper Limit.	Lower Limit.
Hydrogen	66.4	9.45
Illuminating gas	19.1	7.9
Methane (marsh gas)	12.8	6.1
Alcohol vapor	13.65	3.95
Ether vapor	7.7	2.75
Benzin vapor	4.9	2.4

The explosive limits, however, are dependent to some extent upon the size and shape of the containing vessel and upon the character of the ignition (strong electric spark, weak spark, or flame).

It will be observed that the proportion of combustible gas required to form an explosive mixture with air is very small, except in the case of hydrogen. Explosion may be caused by the presence of less than 3 per cent of ether or benzine vapor in the atmosphere. In general, however, the danger of explosion is proportional to the range of explosiveness, i. e., the difference between the upper and lower explosive limits, and is consequently greatest in the case of hydrogen.

The danger of explosion can obviously be averted by preventing the mingling of the combustible gas with air. The idea, still widely prevalent, that certain gases are explosive in themselves, is erroneous, as was proved in a very striking manner by Samuel Clegg at the installation of the first gas-house in London. To the consternation of the examining commission Clegg bored a hole in the wall of the gas-holder and ignited the issuing stream of gas. A long flame shot out, burned quietly, without the slightest explosion, until it was extinguished by the sinking of the gas-holder bringing the hole below the level of the surrounding water. When an attempt was made to blow up a Glasgow gas house with dynamite only the iron parts were shattered, and the escaping gas burned without explosion. In such cases the ignition of the escaping gas is a safeguard against explosion as it prevents the formation, in large quantities, of explosive mixtures of gas and air.

Even an explosive mixture can be prevented from exploding by the addition of an inert gas. This is of great practical importance because such an inert gas is available in large quantities in the carbon dioxide which constitutes from 8 to 14 per cent of the chimney gas of steam boiler furnaces. Eitner and Trautwein have proved that any mixture of illuminating gas and air can be made inexplosive by the addition of 7½ per cent of carbon dioxide. This fact is utilized for the prevention of explosion due to the mingling of gas and air in the first filling of new gas holders and gas pipes. Furnace gas is blown through the system before the illuminating gas is admitted.

In even the most explosive mixtures explosion can be prevented by cooling below the temperature of ignition. A jet of such a mixture, issuing from a tube a diameter less than 1/12 inch, may be ignited without exploding the mixture inside the container, because of the cooling effect of the walls of the small tube. The construction of Davy's safety lamp for miners is based on this principle. The flame is inclosed in fine wire netting, which is equivalent to a multitude of small tubes. Fire damp (methane), if present in the air of the mine, enters the net and burns therein, without exploding the mixture of gas and air outside.

Some explosive mixtures of gases are usefully employed in heating by gas, in incandescent gas lighting, and in explosion motors. All gas heaters and incandescent burners operate on the principle of the Bunsen burner, which automatically mixes the illuminating or fuel gas, before combustion, with a quantity of air. In gas stoves this addition of air is made in order to produce a non-luminous flame, to prevent the blackening of objects exposed to the flame, and to assure complete and odorless combustion of the gas. These objects are the more perfectly attained the larger the proportion of air that is added to the gas. When illuminating gas at the usual pressure, however, is mixed with more than thrice its volume of air (a quantity insufficient for complete combustion) the velocity of efflux is less than the velocity of propagation of ignition, so that the flame "strikes back." The quantity of air added can be increased by increasing the pressure of the gas. This is especially advantageous in incandescent gas lighting where it is desirable to concentrate the combustion in a small space in order to produce a high temperature, and, consequently, an intense luminosity.

In explosion motors it is advantageous to use as little gas as possible, i. e., to approximate as closely as possible to the lower explosive limit. Richer mixtures (corresponding to the upper limit) cause violent explosions, which are far less completely utilized by the moving parts than the mild explosions and expansion produced by mixtures poor in gas. With some mixtures, especially hydrogen and air, these violent explosions may destroy the motor. The operation of explosion motors with very small quantities of gas or vapor is facilitated by the fact that the explosive range is considerably extended at the high temperatures and pressures that prevail in the interior of the cylinder. These principles have been utilized so fully in recent years that the motors of automobiles have attained a perfection that no one would have ventured to predict twenty years ago. This remarkable development is due to increased knowledge of the behavior of explosive mixtures of gas, and this knowledge has been acquired from practice, not from purely scientific researches. In this field practice is far ahead of pure science.

* Translated from Victor Rodt's article in *Die Umschau.*

Notes on the Geology of Texas*

In the northwest part of the State, east of the Pecos, the formations lie nearly horizontal. This structure prevails over the entire Plains, extending from the north end of the Panhandle to a line joining San Angelo and Pecos on the south. This area measures 330 miles from north to south and 170 miles from east to west. The deeper lying rocks can hence be known here only from inferences based on their appearance in distant outcrops outside of this area and from such local observations as may be obtained from deep explorations. It is singularly fortunate for our knowledge of the stratigraphy of this part of the continent that a deep boring was made at a point not far from the central part of the area defined. The exploration enables us to know by actual observation what strata underlie. It furnishes a first-hand information of the stratigraphy of this part of the State.

The deepest boring in Texas is now at Spur, in Dickens County, and was made in search of water for the town of Spur, and as a general exploration of the formations of the vicinity. The hole was abandoned and wrecked in November, 1913, at the depth of 4,489 feet. The remarkable feature of the boring was the continuity and the persistency of the rock. The log shows what a tremendous bed of rock was penetrated.

The strata explored by this boring constitute three well marked divisions. The upper 1,250 feet consist of red sands, clays, marls, beds of gypsum, anhydrite, and salt, all in different gradations of purity and intermixture. This is the Permian Red Beds, constituting a part of the Double Mountain formation. The succeeding 2,850 feet consist of dolomite, with strata of anhydrite, sandstone, and shale. These are probably to be correlated with the Delaware formation west of the Pecos and are, no doubt, the equivalent of the Wichita and the Albany, the Clear Fork, and part of the Double Mountain formation. The lowest 389 feet of the section explored consist of limestone and shale, which are believed to correspond to the upper part of the Cisco formation of central Texas.

* From the *Bulletin* of the University of Texas. "The Deep Boring at Spur," by J. A. Udden, geologist for the Bureau of Economic Geology and Technology.

The uppermost 300 feet of the Red Beds consist of fine silt and clay impregnated with iron oxide, which gives it mostly a deep red color. From 400 to 900 feet below the surface the Red Beds consist for the most part of fine red sand or sandstone. The lower 350 feet of the Red Beds consist of a sandy silt mixed with varying amounts of salt, in which the sand and silt particles are imbedded as in a matrix.

There were three beds of pure salt; one ten feet thick, from 570 to 580 feet below the surface; another five feet thick, from 633 to 638 feet; and a third nine feet thick, from 732 to 741 feet. The upper bed consists of white granular salt showing thin red seams about a half millimeter apart, due to the presence of red silt. The lowermost bed is clear, crystalline sale which is transparent, except for imbedded blotches of silt which shows no well-marked stratification.

At Spur, as elsewhere, the most characteristic persistent ingredient in the sediments of the Red Beds consists of calcium sulphate minerals, gypsum, and anhydrite.

From 1,250 feet below the surface down to 4,095 feet the drill was going through what is essentially a formation of dolomites, interrupted by beds of sandstone, shale, and anhydrite, the last of which is to some extent of secondary origin. The thickness of this series is 2,845 feet.

The main accessory sediments in the dolomitic beds are sand, shale, and anhydrite.

In many of the thin sections of dolomite, black, brownish, or yellowish streaks were noted, that evidently were not iron or manganese oxide. On heating parts of some of these samples, and several others, in a closed tube, it was found that nearly all such rock yielded fumes of bituminous materials. In several cases, perceptible films or even minute drops of oil were obtained.

Fragments of limestone first began to appear with the cuttings from 4,100 to 4,105 feet. After its first appearance, the limestone increased in quantity steadily in the returns for the next forty feet. Below 4,150 feet the samples contained but little dolomite, consisting mostly of limestone and shale, down to the bottom of the well.

It is believed that the strata penetrated by the lowermost 394 feet of this boring are to be correlated with the upper part of the Cisco formation in the central part of the State. They consist of limestone and shale. Limestone is the chief rock from 4,100 to 4,400 feet, while the lowermost 89 feet are mostly shale.

Only a few macroscopic fossils were seen. These were in a core taken between the depths of 2,244 to 2,264 feet. All other fossils were minute forms, found either in thin sections of dolomite and limestone or recovered by washing the triturated material in samples of cuttings taken by the drillers.

The principal fossil-bearing horizon is the Cisco, the lowermost 389 feet of the exploration. Fossils occur in the limestone as well as in the shale. Fusulina, Rhombopora, other bryozoa, and crinoid stems were noted most frequently in the limestone. Chitinous and other agglutinate foraminifera, jaws of annelids, and spicules of sponges were most frequent in the shales. A majority of these fossils are known from the Carboniferous in Europe and America, a few are known from the Permian, and some have probably not been reported from any other locality.

A few fossils were noted at scattered intervals in the samples coming from the shaly dolomite beds.

This boring emphasizes the fact, long known, that water is very scarce in the Pennsylvanian and the Permian sediments on the plains of the Southwest, and also that most of the water they contain is too salty for use. The chances are that, if any deep potable water will ever be found in the Red Bed area, it will come from below the Pennsylvanian, and perhaps below the entire Carboniferous, at some depth exceeding 5,000 feet. There can be little doubt that there are at least several hundred, and probably more than a thousand, feet more of Pennsylvanian strata under the bottom of this boring. The existence of such deep water is highly improbable.

What may eventually be the most important economic result of this boring is that it has proved the existence in the dolomite beds of a stratum, or horizon, from which comes a water sufficiently rich in potash to hold out inducement to prospective search for this mineral.

Considering the great value of a workable deposit of potash, it seems worth the while to call attention to another circumstance in connection with these observations. In either direction north or south from Spur the formations lie practically horizontal for at least a hundred miles, and the potash-bearing horizon, whether it be such or not in other places, must be at about the same depth as here, in these directions. It seems to the writer that the general conditions indicated in this boring, the existence of great salt beds and beds of anhydrite, together with the proven potash-bearing stratum, warrants an examination for potash in water from the same horizon in any boring made in this territory.

The rocks of the dolomitic beds, and still more the rocks of the Cisco, must be regarded as sufficiently bituminous to produce large accumulations of oil and gas under favorable structural and lithological conditions. But the fact that the entire column of formations explored in the well below the Red Beds consists of compact sediments that not even yield salt water, shows that the rocks are not in this locality sufficiently porous to have permitted the accumulation of any fluids they may have contained. Everything considered, the prospect for oil or gas in this vicinity must be regarded as decidedly discouraging.

The Work of a Naval Wireless Operator in Times of War*

WAR! Martial law has been proclaimed, the fleets have been mobilized, and the battle maneuvers are now being "practised" in deadly earnest. It is one thing to repel a friendly enemy; it is quite another when the opposing naval forces are, next to our own, the finest in the world.

Let us suppose we are reconnoitering in hostile waters. The cruisers are ordered to spread themselves out in the vanguard of the fleet on lookout duty; they steam along without lights of any description. These great vessels, invisible as the night can make them, are brooding on the troubled waters. Yet they are very alive. Ceaselessly they communicate one with another, for in each vessel, hidden as far as possible from external view, is the soundless and padded wireless room. Here the operator is at work, the electric lamp glowing brilliantly above him; but a messenger enters with an order from the commander; immediately, as the handle of the door is touched and pulled open by the entrant, the lights go out, and pitch darkness prevails, until once again the door is closed behind him, and automatically the lights are switched on—that is part of the secrecy which prevails on a battleship in time of war. The men on lookout duties are stationed in various parts throughout the cruiser; their duty is to keep their eyes open, as there is always a chance that one of the enemy's destroyers may come rushing along at a speed of some 30 knots an hour, shoot a torpedo into the ship, and get away unscathed. At the best of times it takes a cunning gunnery to strike a vessel going at this speed; but in the darkness possibilities of the marauder's escape are increased tenfold, and only the eyes of the crew and watchers can, as far as possible, safeguard mishap. As soon as anything is sighted, it is reported to the battle fleet. This is done by the wireless, and the operator is compelled to work at high pressure, for he has to read every message a cruiser sends, inform his captain, and himself get in touch with the fleet if his officer should desire to send a reply. Then there is the admiral of a fleet to be considered. The operator must keep a good lookout in case some battle order should be transmitted from this important quarter.

All this time, remember, the ship is cruising at imminent risk, not only from the actual attacks of a secret enemy, but from the danger of floating mines and even aerial attack. It requires no little personal courage, therefore, for the operator to remain in that closed wireless cabin, whence, should disaster occur, there is no chance of escape, and all the time he must keep his head, and send and receive messages with as much nonchalance as though he were seated at home in the security of his own little den. But quiet heroism is one of the traditions of wireless service.

Very few people realize the great importance of wireless telegraphy, especially in time of war or strained relations. We will take, for instance, a fleet of battleships at sea while their country is at war with another power. Each ship in that fleet has its wireless installation, adjusted so that they can send and receive signals and messages to other squadrons at sea or in harbor and to stations ashore. One ship of that fleet is always in direct touch with the Admiralty. The chance of interference from an enemy's ship is reduced so as to be almost not worth counting. Each ship in a battle fleet is responsible for some station ashore, or for a cruiser squadron or flotilla of torpedo-boat destroyers.

The importance of having one ship in a fleet always looking out for messages from the Admiralty can be easily seen. All foreign intelligence and the movements of foreign ships go to the capital by telegraph, cablegram, and wireless from different parts of the world, and from thence it is transmitted to the admiral in charge of the fleet, who directs his ships accordingly. The whole safety of a battle fleet depends on wireless telegraphy in time of war. When a number of battleships are steaming along, perhaps looking for the enemy, it would not do for them to run into a superior number of the enemy's battleships.

To guard against this, a great number of cruisers are sent out ahead, and spread a number of miles across. The duty of these ships is to keep a thorough lookout and report to the ship in the battle fleet looking out on their particular tune. This ship, in turn, reports by semaphore or morse-lamp to the admiral of the battle fleet. The cruisers are sometimes assisted by torpedo-boat destroyers. Now, if 30 of these ships are used, it will be readily seen that the area of their vision is enormous, and it would be almost impossible for a fleet to pass unobserved. Immediately any of the ships sight the enemy's squadron, they would report at once by wireless, stating the number of ships sighted, with their speed, latitude, and longitude, etc. The admiral would then give his orders, also by wireless. If the admiral determines to attack, he directs the cruisers to steam at full speed, and take refuge behind the battle fleet.

* From the *Wireless World* for September.

Making a Comparison Spectrum

IT is often necessary when making a study of spectra, either terrestrial or celestial, to have a comparison spectra which is capable of furnishing certain of the standard lines. In the *Annual* of the Observatory of Good Hope, J. Lunt suggests that a convenient source for this has been found in the graphite of an ordinary lead pencil, which generally contains sufficient impurities to give lines of iron, titanium, vanadium, chromium, barium, strontium, calcium, and often gallium, scandium, yttrium, silicon, magnesium, manganese, in addition to the carbon.

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